Teaching the Math Anxious Female Student:
Teacher Beliefs about Math Anxiety and Strategies to Help Female Students in All-Girls Schools

By

Megan Clark

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

This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 2.5 Canada License
Abstract

Math anxiety is a prevalent issue in our education system today. Despite this prevalence, little on the topic of this anxiety is formally addressed in schools. This research investigates the potential causes and effects of math anxiety in female students as well as strategies that teachers can implement in their classroom to alleviate this anxiety. I conducted semi-structured interviews with four math teachers at all-girls independent schools who are aware of this issue and are actively working to help their students. The qualitative data collected from these interviews was analyzed for common themes. Findings regarding teacher beliefs about the causes of math anxiety in female students formed four categories: parental influences, school influences, internal influences and societal influences. Common themes that arose in the data regarding the effects of math anxiety include avoidance and lack of confidence in mathematics. These themes were closely related to ideas that emerged from the literature or provide further insight into math anxiety as experienced by female students in single-sex classrooms. Effective classroom strategies used to help female students with mathematics anxiety are also discussed at length, along with challenges experienced by the participants and their desired opportunities for professional development.

Keywords: math anxiety, mathematics anxiety, mathematics education, female mathematics education, single-sex mathematics education
Acknowledgments

There are several people that I would like to acknowledge with gratitude who have helped me greatly throughout the research process. Firstly, I would like to especially thank my research supervisor, Limin Jao, for her insight, approachability and enthusiasm throughout my research. I must also extend sincere gratitude to Ron Lancaster and Anthony Meli for their kindness and willingness to answer all of my many questions about math education. A very special thank you to the participants of the study, who, without their experience, openness and candor, this research study would not have been possible. I would also like to thank my course instructors in the Master of Teaching program for their continued support and suggestions throughout the process and in helping me develop as a professional and as a researcher. Thank you as well to Mike Carlson, Erin Woods, Samantha Scheepers and Alessandro Bresba, for their support and suggestions throughout the development of my research paper. Finally, I would like to thank my family and friends for their continued support, love and prayers throughout my undergraduate and graduate education.
Table of Contents

Abstract .................................................................................................................. 2
Acknowledgments ................................................................................................. 3
Table of Contents ................................................................................................. 4

Chapter 1 Introduction ......................................................................................... 6
  Introduction to the Research Study ................................................................. 6
  Researcher’s Background ................................................................................. 6
  Purpose of the Study ......................................................................................... 8
  Research Questions ......................................................................................... 9
  Overview ......................................................................................................... 10

Chapter 2 Literature Review .............................................................................. 11
  Definition of Math Anxiety ............................................................................ 11
  Causes of Math Anxiety ................................................................................ 11
    Family influences ......................................................................................... 11
    School influences ......................................................................................... 12
    Internal influences ....................................................................................... 14
    Societal influences ....................................................................................... 15
    Neurological considerations ....................................................................... 15
  Effects of Math Anxiety .................................................................................. 16
  Strategies for Reducing Math Anxiety in the Classroom ............................... 17
    Identification and understanding ................................................................. 17
    Integrating emotion in the classroom .......................................................... 18
    Use of technology ........................................................................................ 19
    Relevance to the real world ......................................................................... 19
    Collaborative learning .................................................................................. 20
    Awareness of multiple intelligences and learning styles ............................ 20
    Student self-assessment and formative assessment .................................... 21
    Creating a positive classroom environment .............................................. 22
    Encouraging risks and building on mistakes ............................................. 22
    Teacher self-reflection .................................................................................. 23

Chapter 3 Methodology ....................................................................................... 24
  Participants ....................................................................................................... 24
  Procedure .......................................................................................................... 25
  Data Collection and Analysis ......................................................................... 26
  Ethical Review Procedures ............................................................................. 27
  Limitations ....................................................................................................... 28

Chapter 4 Findings ............................................................................................... 29
  Awareness of Math Anxiety ............................................................................ 29
  Causes of Math Anxiety ................................................................................ 29
    Family influences ......................................................................................... 29
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>School influences</td>
<td>30</td>
</tr>
<tr>
<td>Internal influences</td>
<td>32</td>
</tr>
<tr>
<td>Societal influences</td>
<td>33</td>
</tr>
<tr>
<td>Effects of Math Anxiety</td>
<td>34</td>
</tr>
<tr>
<td>Strategies for Reducing Math Anxiety in the Classroom</td>
<td>35</td>
</tr>
<tr>
<td>Identification and understanding</td>
<td>35</td>
</tr>
<tr>
<td>Student and teacher language</td>
<td>36</td>
</tr>
<tr>
<td>Building positive student-teacher relationships</td>
<td>36</td>
</tr>
<tr>
<td>Talking with students individually</td>
<td>37</td>
</tr>
<tr>
<td>Collaborative learning</td>
<td>38</td>
</tr>
<tr>
<td>Allowing students to feel connected to the math</td>
<td>39</td>
</tr>
<tr>
<td>Encouraging risks and building on mistakes</td>
<td>40</td>
</tr>
<tr>
<td>Partnering with stakeholders</td>
<td>40</td>
</tr>
<tr>
<td>Use of technology</td>
<td>41</td>
</tr>
<tr>
<td>Teaching relaxation techniques</td>
<td>42</td>
</tr>
<tr>
<td>Teaching the growth mindset</td>
<td>42</td>
</tr>
<tr>
<td>Assessing the Effectiveness of the Strategies</td>
<td>43</td>
</tr>
<tr>
<td>Challenges</td>
<td>44</td>
</tr>
<tr>
<td>School climate</td>
<td>44</td>
</tr>
<tr>
<td>Curriculum</td>
<td>44</td>
</tr>
<tr>
<td>Professional Development Opportunities</td>
<td>45</td>
</tr>
<tr>
<td>Chapter 5 Discussion</td>
<td>47</td>
</tr>
<tr>
<td>Connections to the Literature</td>
<td>47</td>
</tr>
<tr>
<td>Awareness of math anxiety</td>
<td>47</td>
</tr>
<tr>
<td>Causes of math anxiety</td>
<td>48</td>
</tr>
<tr>
<td>Effects of math anxiety</td>
<td>50</td>
</tr>
<tr>
<td>Strategies for teachers</td>
<td>51</td>
</tr>
<tr>
<td>Implications for the Current and Future Teacher</td>
<td>55</td>
</tr>
<tr>
<td>List of Recommended Practices</td>
<td>57</td>
</tr>
<tr>
<td>Limitations and Areas for Further Study</td>
<td>59</td>
</tr>
<tr>
<td>Conclusion</td>
<td>60</td>
</tr>
<tr>
<td>References</td>
<td>61</td>
</tr>
<tr>
<td>Appendices</td>
<td>64</td>
</tr>
<tr>
<td>Appendix A: Letter of Consent for Interview</td>
<td>64</td>
</tr>
<tr>
<td>Appendix B: Interview Questions</td>
<td>66</td>
</tr>
</tbody>
</table>
Chapter 1 Introduction

Introduction to the Research Study

The word *mathematics* is scary for some people. Although both mathematical literacy and language literacy are of high value in our education system, many people openly proclaim their difficulties in math but would never announce that they could not read or write. For some reason, in both the school setting and in large-scale society, there seems to exist a general acceptance of the inability to succeed in mathematics. A lack of confidence in math can result in a feeling of anxiousness when performing in mathematical situations (Stuart, 2000). Although this phenomenon has been given many names, it will be referred to in this study as “math anxiety”.

Research has shown that females and males experience math anxiety differently. Eccles (1984) explains that females tend to attribute their successes in math to ability, whereas boys tend to relate the same outcome to effort (as cited in Tobias, 1993). This tendency has been shown to have a correlation with higher levels of anxiety and lower levels of interest in math for females (Pajares & Graham, 1999). Furthermore, this anxiety is less present in female students in single-sex environments than female students in co-educational environments (Norton & Rennie, 1998). Therefore, the evidence of female math anxiety in all-girls schools may suggest that math anxiety is an issue even in environments that are perceived to foster lower levels of anxiety. Thus, through this research study, I will attempt to highlight the beliefs that teachers in all-girls schools have about math anxiety in female students and the strategies that have been effective in helping these students in the math classroom.

Researcher’s Background

From a very young age, I was privileged with the ability to understand and enjoy math. My father, a secondary math teacher, has always encouraged my enthusiasm in the often feared
Throughout my school-aged years, I began to realize that my love of math was somewhat unusual and that as I reached higher grade levels, fewer people around me shared this common interest. When others would learn how much I liked math, many would react with “Wow, you must be a genius!” or “You have got to be crazy.” In my opinion, I was neither of those things.

I never really understood why so many people felt such a strong opposition to math until my second year as an undergraduate student at McMaster University. It was then that I became a Calculus teaching assistant and my love of math transformed into a passion for teaching. It was also through this experience that I became even more aware of the issue of math anxiety within our education system.

During my office hours and while assisting in the Math Help Centre, I spoke in detail with several students, mostly females, about how they believed they developed their anxiety in mathematics. Their responses ranged from a very specific traumatizing experience to a general misunderstanding of the relevance and applicability of the subject matter. One of my students even remembered a specific time when she scored lower in math than in any other area on the Grade Three EQAO test. This result lead her to conclude that she would never be adept in mathematics. Another student believed that her inability to perform in math just ran in her family. Overall, many students I have worked with were physically, mentally and emotionally affected by math. This negative reaction to math often resulted in a negative attitude towards the subject matter, extreme panic before assessments and at times a complete avoidance of mathematical tasks for fear of failure.

In my practice teaching experiences through the Master of Teaching program, I witnessed even more evidence of the existence of math anxiety in our education system. On the first day of
one of my placements, I distributed a questionnaire to my students that asked them general questions about their learning preferences, background in math, future studies in math as well as their general attitude towards the subject. It is important to note that these students were all part of a Grade 12 Academic math class and most were continuing on to pursue post-secondary studies that would involve math to some degree. The average out of 10, where 1 was a strong dislike for math and 10 was a strong affiliation for mathematics, was 6. The students who decided to share specific reasons for their rating described the inapplicability of the subject matter to the real world, the boring nature of the lessons and the difficulty level of the concepts. Some students gave no specific reason, but simply deemed themselves as “just not capable”.

When I read these questionnaires, I immediately began to ask myself how the students had developed this attitude towards math. Specifically, why is math integrated into every aspect of the world around us but that our math curriculum at times seems to have separated all relevance? Why do the students find one of the most amazing and intricate subjects to be boring? Why do the students feel incapable in math? In my experience, I have heard more people say that they are incapable in math than in any other subject. By any standard, this apprehension towards math affects both the education system and the society at large. I have therefore become determined to study this issue more closely.

### Purpose of the Study

As a teacher candidate that will soon be thrust into the world of math education, I find myself wondering what has happened in society and in the education system to facilitate an overall negative perception of mathematics. With math anxiety at the heart of many struggling students, I believe that measures must be taken within the education system to come to a solution.
Research has shown that a reduction in math anxiety can result in better achievement in math (Hembree, 1990). For the purpose of this study, I focus on math teachers in all-girls schools who teach female students with math anxiety and are actively working to help these students to succeed. My research study sheds light on the prevalence of math anxiety in students in all-girls schools and provides insight into the beliefs of math educators in all-girls schools about the causes and effects of math anxiety. Furthermore, this study also outlines effective strategies used by teachers to help female students cope with their anxiety and to succeed in mathematics.

Through this research study, I hope to not only build my repertoire of strategies for effective math education but also to share these strategies with all teachers. Furthermore, I hope this research paper will teach me the essential skills involved in performing reflective and effective research in education. Overall, I envision an education system in the future that supports a positive attitude towards math and an ongoing engagement of all students in the math classroom. The first step in this direction involves teachers educating themselves about math anxiety and actively implementing strategies to help their students in the classroom.

**Research Questions**

The principal question that will be addressed in my research is: What do educators in all-girls schools believe to be the causes and effects of student math anxiety and what strategies do they use to help their students mitigate the anxiety?

The following questions will support the principal research question:

1. How do educators in all-girls schools assess the effectiveness of the strategies they implement in the classroom?
2. What challenges do educators in all-girls schools face when trying to help their students mitigate their anxiety?
3. What professional development opportunities do educators in all-girls schools wish to have surrounding the issue of female math anxiety?

Overview

This paper contains five chapters: Introduction, Literature Review, Methodology, Findings and Discussion. The introduction provides rationale for research on math anxiety in female students by outlining the background of the researcher as well as the purpose of the study. Chapter 2, the literature review, provides a detailed compilation of information on the causes and effects of student math anxiety as well as the strategies that can be implemented by teachers in the classroom. The methodology chapter outlines the data collection process through descriptions of the procedure, participants, ethical review procedures and limitations. Chapter 4 compiles the main themes that arose from the interviews with the participants. Lastly, the discussion chapter provides connections between my findings and the literature review, outlines implementations for the current and future teacher, lists recommended practices for math teachers, restates limitations and suggests areas for future research. The five chapters are followed by a list of references, the participant letter of consent and the interview questions.
Chapter 2 Literature Review

For the purpose of this research study, the topics examined in the literature review will address the definition of math anxiety, the potential causes of this anxiety as well as the effects experienced by students. Some considerations will be made for causes and effects specific to female students. These sections will be followed by a compilation of effective strategies, supported by the literature, to help math-anxious students.

Definition of Math Anxiety

For teachers to help their female students cope with their math anxiety, they must first have a solid understanding about what it means to be math anxious. Math anxiety involves the feeling of tension that can affect the ability to manipulate numbers and solve mathematical problems (Richardson & Suinn, 1972). According to Ashcraft (2002), math anxiety can also be defined as the negative attitude towards, or lack of confidence in, mathematics. This anxiety can manifest into certain physiological reactions including sweaty hands, palpitating heart, mild stomach pains and even tightening of the muscles (Clawson, 1991). The terms math phobia, math fear and math panic have also been used to describe the same phenomena.

Causes of Math Anxiety

Teachers need to understand the root of math anxiety in order to help their students deal with the effects. Each student who experiences math anxiety does so based on a wide range of potential causes. These causes, as drawn from the literature, can fall into the following five categories: family influences, societal influences, school influences, internal influences and neurological considerations.

Family influences.

From a very young age, an individual can be severely influenced by their home
environment. There are instances when parents have expected their children, typically their daughters, to have a natural inability in math (Tobias, 1993). In doing so, parents can contribute to their child's lack of confidence in the area of math (Zaslavsky, 1994). Eccles (1994) reinforces this point by stating that parents who have traditional perceptions about the abilities of their sons and daughters may provide their sons with different opportunities in math than their daughters (as cited in Catsambis, 2005). Furthermore, parents who tend to avoid math can also contribute to their child's anxiety in math. This has been shown to be especially harmful for young girls (Zaslavsky, 1994). Finally, individuals from families of a low socio-economic background are also at a disadvantage in math since they are not typically provided with the extra supports at home or in the community to succeed (Geist, 2010).

School influences.

The school experience can also have a significant influence on a student’s math anxiety. Teachers can serve as a prime determinant of math anxiety in their students, typically during the primary grades but also at the secondary level (Jackson & Leffingwell, 1999). There are many specific ways that teachers can intensify their students’ math anxiety including: forcing students to write answers on the board, responding negatively to questions, demonstrating an insensitive and uncaring attitude towards students and relying heavily on handouts to teach the content (Jackson & Leffingwell, 1999). Teachers can also contribute to math anxiety by giving the impression that mathematical ability is inborn, rather than a skill that can be developed in students (Tobias, 1993).

Some math teachers themselves may experience math anxiety and can therefore pass it on to their students. By exhibiting a general nervousness or a negative attitude towards math, teachers can instill a sense of anxiety in their students (Geist, 2010). More specifically, female
teachers' math anxiety can have a direct and negative effect on achievement in mathematics by female students (Beilock, Gunderson, Ramirez, & Levine, 2010). This effect was shown to result from the perceived reinforcement of the stereotype that boys are better than girls in mathematics (Beilock et al., 2010).

The way math education manifests itself in the curriculum can also contribute to student math anxiety. Math is often taught in discrete parts instead of integrating all the concepts to reach a coherent understanding of the subject matter (Tobias, 1993). School math can therefore be responsible for providing a misrepresentation of mathematics, one that involves mostly memorization, must be completed quickly, is very abstract and requires only one correct answer (Zaslavsky, 1994). With memorization comes a lack of deep understanding and as a result, students can experience a decrease in confidence in their mathematical knowledge (Steele & Arth, 1998). Students can also begin to associate math with mundane work that does not relate in any way to everyday life (Geist, 2010). Moreover, Beilock (2008) discusses how timed assessment tasks, which are very commonly part of mathematics courses, can lead to higher levels of anxiety in females than in males of the same age. Furthermore, streaming in math courses in secondary school can also contribute to a student's math anxiety. Many students can become disheartened if they are placed in a lower achieving class, and most take this to reflect on their ability in math a very negative way (Zaslavsky, 1994).

Finally, the anxiety experienced by female students in math has been shown to differ between single-sex and co-educational environments. Riordan (1990) found that females perform better in math and science at single-sex schools as opposed to co-educational schools where there is less competition and decreased pressure to conform to traditional gender expectations (as cited in Catsambis, 2005). It has also been shown that females in single-sex classrooms experience less
anxiety than females in co-educational classrooms, when measured using the Math Anxiety Rating Scale for Adolescents (MARS-A) (Campbell & Evans, 1997). The higher level of anxiety in female students in co-educational environments is believed to be attributed to an increased feeling of intimidation and competition due to the presence of boys (Campbell & Evans, 1997).

**Internal influences.**

There are interesting observations to be made when examining the self-efficacy of boys and girls based on current and former successes and failures in mathematics. Building on Weiner’s work on the Attribution Theory (1974), Eccles (1985) discovered that most boys attribute their successes in math to effort whereas girls center it on ability (as cited in Tobias, 1993). The majority of boys will use lack of preparation as an excuse for failure, while girls will take it to mean that they are not smart in math (Tobias, 1993). This tendency may consequently result in higher levels of anxiety and lower levels of interest in math for females (Pajares & Graham, 1999). Another explanation for the higher levels of anxiety is worry, the cognitive trepidation about performance (Hong, O’Neil, & Feldon, 2005). Williams (1996) found that females cited higher amounts of worry which an inverse effect on performance (Hong et al., 2005).

Another consideration for internal causes of math anxiety involves the work of Carol Dweck (2006) on mindsets. Dweck (2006) explains that when an individual has a fixed mindset, they see their ability and intelligence as a fixed trait. A growth mindset, on the other hand, involves the perception that ability and intelligence can be improved and developed over time (Dweck, 2006). Although Dweck (2006) does not directly link math anxiety and mindset, she does outline the effects of mindset on achievement in school in general. Therefore, if a student views their failures as an endpoint instead of an area for growth, this self-perception of ability can result in increased levels of anxiety.
Societal influences.

In our society, there exist certain beliefs surrounding math that can have an effect on student math anxiety. Overall, there is a generally accepted opinion that very few people are capable in math (Tobias, 1993). In addition to this general acceptance of mathematical illiteracy in society, certain gender stereotypes are evident that can also influence female students' confidence in their abilities in math. An example of these stereotypes involves the Mattel Barbie, released in 1994, which was programmed to say “Math Class is Tough”. This seemingly innocent child's toy acted to further the existing societal stereotype that females were less successful in math (Zaslavsky, 1994).

Neurological considerations.

Several studies have attempted to find a potential neurological cause for math anxiety. Although there are theories that argue that mathematical ability is inborn, Tobias (1993) argues that every individual is ultimately capable of succeeding in math. Gardner’s theory of Multiple Intelligence may provide a counter-argument for this claim, however, since he stated that there are at least 8 different intelligences, one of which is logical-mathematical (Woolfolk, Winne, Perry, & Shapka, 2010). By his theory, there can be individuals that are simply not programmed genetically to succeed in mathematics. However, it is important to note that Gardner's theory also supports that an individual can work on their weaker areas of intelligence to make them stronger (Woolfolk, Winne, Perry, & Shapka, 2010). On the other hand, the apparent inability of some students to perform in mathematics may not be due to Gardner's theory. Since math anxiety can affect the most competent and intelligent people, low achievement can also be a result of their struggle with math anxiety (Zaslavsky, 1994).

Finally, a neurologically based disorder of mathematical abilities called dyscalculia has been found to cause a discrepancy between an individual’s cognitive ability and mathematical
ability that affects at least 6% of school-aged children (Wadlington & Wadlington, 2008). Its symptoms include difficulty understanding and manipulating numbers and can result in the experience of math anxiety (Wadlington & Wadlington, 2008). Since the symptoms of dyscalculia and math anxiety do overlap, however, there can be misdiagnoses of mathematical disabilities in students suffering from math anxiety (Wadlington & Wadlington, 2008).

**Effects of Math Anxiety**

There are several ways that math anxiety can manifest in female students. These effects can be used as indicators by educators to identify math-anxious students. The principal factors that emerged from the literature are avoidance, attitude and affective drop in performance.

A primary indicator that a student may be experiencing math anxiety is avoidance. Students with high levels of math anxiety tend to take fewer high school math courses, avoid selecting college or university courses that involve math and turn away from mathematically influenced career paths (Ashcraft, 2002). It is also very likely that this avoidance would be observable in the classroom in the form of minimal participation, failure to complete homework and less time spent on studying (Ashcraft, 2002). Tobias (1993) speaks about a higher level of avoidance that exists in females at crucial levels of their schooling, specifically during the middle years of Grades 7-9, compared to males of the same age. She continues, however, to state that individuals of both genders tend to stop taking math during high school, much before the end of their formal education (Tobias, 1993).

Individuals who experience math anxiety can also exhibit poorer attitudes towards math than those who do not experience any anxiety (Ashcraft, 2002). This negative attitude tends to result from a lack of confidence in their abilities and a lack of faith in their intuition (Tobias, 1993). Math-anxious students may also feel negatively towards math if they feel a lack of control
over their learning (Tobias, 1993).

Math anxiety has also been found to cause a drop in performance when math is performed under timed, pressured conditions such as a test or exam (Ashcraft & Moore, 2009). In other words, it has been shown that the higher one's math anxiety is, the lower their score will be on achievement tasks in math (Ashcraft, 2002). This drop in performance, therefore, can ultimately reflect an underestimation in the true ability of the individual (Ashcraft & Moore, 2009). This low level of performance can also result from the possible avoidance factor, poor attitude or lack of confidence towards mathematics.

With an understanding of the potential causes and effects of math anxiety, the next step for educators is to be aware of the strategies that can be used to help their students. There are many strategies suggested by the literature which can be effectively implemented in the mathematics classroom.

**Strategies for Reducing Math Anxiety in the Classroom**

It is crucial for educators to understand that each student, whether math anxiety is involved or not, deserves equal opportunity to succeed in mathematics. The ability to succeed in mathematics is not only important because of the impact it has on the students in their academic career, but also due to the value of mathematics in their everyday lives. Teachers can play a vital role in helping their students cope with math anxiety and must always strive to practice the most effective strategies possible to encourage the success of their students.

**Identification and understanding.**

The first stage in any treatment process is identification and diagnosis (Tobias, 1993). In order for a teacher to help students deal with math anxiety, they must first have an understanding of where it originated (Furner & Duffy, 2002). Students also need to come to an understanding of
where their anxiety first arose and what specific situations trigger their strong negative reaction to math (Tobias, 1993).

There exist several explicit tests that can be used to explicitly identify if an individual is experiencing math anxiety. These include, but are not limited to, the Math Anxiety Rating Scale developed by Richardson and Suinn (1972) and the Fennema and Sherman's Math Anxiety Scale (1976) (as cited in Sherman and Wither, 2003). Although math anxiety is at times difficult to separate from test anxiety, Hembree (1990) concluded that they are in fact separate (Sherman & Wither, 2003).

Tobias (1993) states that the best way to really understand where a student’s math anxiety comes from is through one-on-one interviews. Although this may be quite time consuming for the teacher, it can be hugely beneficial for both the student and the teacher. The teacher can gather feedback about the student's feelings and perceived program that can inform future instruction and assessment. The student can gain advice about next steps as well as develop a positive relationship with the teacher.

**Integrating emotion in the classroom.**

Integrating feelings about math into the classroom can also help students cope with their negative attitudes towards the subject (Tobias, 1993). Some specific methods that can be used include T-charts, math journals, self-reflections and surveys (Furner & Duffy, 2002). A T-chart, for example, can be used when solving a mathematical problem. On the left side of the chart, the student attempts to solve the problem, while the right hand side can be used to write how he or she is feeling and where there may be confusion. This strategy allows the students to express their feelings, ask questions and ultimately can inform the teacher about where problems may be happening (Furner & Duffy, 2002). It is also important to understand that simply being aware of
these issues is not enough. Teachers must take what they observe and hear from their students about their feeling towards math and create realistic ways of combating these issues in the classroom (Furner & Duffy, 2002).

**Use of technology.**

The use of technology in the math classroom can also help to reduce the anxiety of the students (Furner & Duffy, 2002). The current generation of students as “digital natives”, those who have grown up surrounded by technology, are adept and efficient in the use of technological devices (Prensky, 2001). Technology and all of its applications can therefore be used in mathematical investigation and can give the students a sense of excitement and purpose in math (Ashcraft, 2002). Technology can also give representation to the mathematical problems that arise in daily situations (Furner & Duffy, 2002). This can ultimately foster more motivation and result in less frustration in mathematical problem solving. Dynamic geometry software such as Autograph, Geometer’s Sketchpad and Geogebra are all tools that can be incorporated into the classroom to assist students in visualizing mathematics.

**Relevance to the real world.**

Students have a hard time reacting positively to math when it is not made relevant to their lives. Stuart (2000) argues that teachers who are able to make math relevant in the classroom can have a huge impact on the positive perception of math by students. New concepts in math should also aim to link with prior knowledge and experiences that have been had by the students (Furner & Duffy, 2002). Students want to know that their past efforts have not been wasted and that math can be applicable to their everyday lives, despite the apparent abstract and seemingly irrelevant nature of mathematics. Examples of real-world problems include using graphs to examine the employment rates of females versus males over the past century and using proportional reasoning
to shed light on unequal wealth distribution in the countries of the world.

**Collaborative learning.**

Collaborative learning has been shown to be effective in all academic contexts, and can be effectively applied to the math classroom (Tobias, 1993). By learning from and teaching other peers, students can develop confidence in their abilities, thereby lessening their feelings of anxiety (Lavasani & Khandan, 2011). Powel and Enright (1990) also found that collaborative, or cooperative, learning can result in a decrease in anxiety and an increase in self-awareness and self efficacy. This decrease in anxiety has been believed to be a result of a lesser degree of competition in a collaborative learning environment and has been shown to be especially effective for female students (Batton, 2010; Johnson & Johnson, 1989).

Interactive math activities can also foster positive attitudes about math and encourage collaboration and support among students (Tobias, 1993). Collaboration can also aid in the improvement of communication skills through working with and teaching fellow peers in math and encourages cooperation rather than competition (Wadlington & Wadlington, 2008). Such activities can include student centered investigations, problem-based learning scenarios and other group work techniques such as jigsaws or four corners activities.

**Awareness of multiple intelligences and learning styles.**

Gardner's theory of multiple intelligences can help teachers understand that each student differs in the areas of their strengths and weaknesses. Teachers must also be aware that there are a wide variety of different learning styles that can affect the academic performance of their students, such as visual, auditory and kinesthetic (Geist, 2010). Differences in learning styles of boys and girls need to also be considered since teaching all students in the same way, and not accommodating for differences in learning styles, can heighten math anxiety (Geist, 2010). Once
teachers understand the situations in which each of their students excel, they can create activities that allow their students to demonstrate their strengths and abilities leading to more confidence in math (Wadlington & Wadlington, 2008). Through these activities, teachers can differentiate their instruction in order to accommodate for different levels of readiness, varied interests and learning styles (Tomlinson, 1999). Differentiated instruction can ultimately support student success and further their academic growth (Landrum & McDuffie, 2010).

By encouraging creativity in the classroom and emphasizing original thought over manipulation of formulas, teachers can become aware of how students are thinking about the problems and can use this to inform their instruction (Stuart, 2000). Incorporating students’ interests into classroom activities can make learning more enjoyable and can encourage all students, especially those struggling with math anxiety (Stuart, 2000).

**Student self-assessment and formative assessment.**

It is very important for teachers to understand that allowing their students to become a part of their own assessment can have a positive influence on their learning. By letting students have input on their own evaluations, they can feel a sense of control over their learning which can create a greater sense of worth in the classroom (Stuart, 2000).

Wadlington and Wadlington (2008) argue that teachers should give positive feedback frequently for all types of success. Moreover, students’ abilities in math should never be a measure of their self-worth (Stuart, 2000). Research has shown that providing students with formative assessment opportunities and regular descriptive feedback increases motivation and self-efficacy in the classroom (Brookhart, Moss, & Long, 2008). Therefore, teachers should place more value on the process than the product, thus allowing the students to become motivated to work hard and to improve their abilities in mathematics. Teachers can also encourage students to
pursue, and not shy away from, challenging math courses and math competitions that can further their abilities (Scarpello, 2007).

**Creating a positive classroom environment.**

Creating a comfortable classroom environment is important in reducing student math anxiety. This can be accomplished in many different ways, including: incorporating students’ interests into class work, providing time outside of the classroom for help, always trying to create lessons that will engage all students and incorporating choice into the classroom (Furner & Duffy, 2002). Stuart (2000) argues that teachers must create classroom environments that encourage students to build on their prior knowledge, investigate and problem solve, while ultimately increasing their confidence in mathematics.

**Encouraging risks and building on mistakes.**

To reduce anxiety in the math classroom, teachers should encourage risk-taking. Taking risks in mathematics can be especially difficult for students experiencing mathematics anxiety and can lead to apprehension and avoidance (Steele & Arth, 1998). Teachers should emphasize that taking risks and making mistakes is an integral part of the learning process (Stuart, 2000). By accepting more than one way to express a solution, student participation and confidence in intuition can increase (Steele & Arth, 1998). When a student makes a mistake, this can be an opportunity for the teacher to help the student arrive at a deeper understanding of the problem (Steele & Arth, 1998). Furthermore, students should never feel afraid to receive punishment or ridicule from teachers or classmates for incorrect answers (Wadlington & Wadlington, 2008). Teachers can help by showing students the rough work they did in order to prepare for a lesson (Tobias, 1993). Teachers can also discuss several famous individuals, such as Einstein or Churchill, who overcame difficulties to become very successful in their careers (Wadlington &
Teacher self-reflection.

Teachers must be aware of their own anxieties related to mathematics. If a teacher has overcome math anxiety, or perhaps still struggles with it, he or she can share their experience with the class to demonstrate the value of hard work (Furner & Duffy, 2002). Since research has shown that a teacher’s attitude toward math can intensify the math anxiety of his or her students, teachers who experience anxiety must also take steps in dealing with these issues. One way to do this would be to seek help from fellow colleagues for support (Furner & Duffy, 2002). Teachers can also read literature and educate themselves on the effect their math anxiety can have on their students.

Educators should also be aware of their own judgments. Those who believe that math ability is incremental, or can be changed over time, see their students as able to continually improve their skills (Woolfolk, Winne, Perry, & Shapka, 2010). Stipek (2002) found that teachers who believe ability is a fixed entity are more likely to make quick judgments about the level of their students (as cited in Woolfolk et al., 2010). Educators should value and accept all pupils, set clear expectations and help students set attainable goals and objectives for themselves.
Chapter 3 Methodology

My research on teacher beliefs about female math anxiety and the ways in which teachers at all-girls schools can help their students in the classroom was conducted by first examining and compiling current research in the field of education on the topic of math anxiety. This review of the literature was then followed by conducting face-to-face interviews with four teachers in all-girls schools. These interviews were transcribed and analyzed for common themes.

Participants

I interviewed four teachers who are aware of the issue of math anxiety and are actively working towards solutions in their classroom. I selected my participants based on connections made through the Ontario Institute for Studies in Education and referrals from former course instructors.

The participants were selected based on the following criteria:

1. They must be currently teaching math at all-girls schools or have had experience teaching math at all-girls schools and willing to speak about their experiences
2. They must be aware of math anxiety and actively addressing this issue in their classrooms

Theresa, has a Bachelors of Science in Physics and a Masters degree in Biophysics. She is currently in her fifth year at an all-girls school and has taught previously for one and a half years in a co-educational school. She currently teaches Grade 7 Math, Grade 9 Science and Grade 11 Physics. Eliya has a Bachelors and Masters degree in Mathematics and is currently a math teacher at a co-educational school. She previously taught for ten years in an all-girls school. She currently teaches Grade 9 Geometry, Grade 10 Geometry and Grade 12 Multi-Variable Calculus. Janet also has a Bachelors degree in Mathematics. She taught for five years in a co-educational
school and is currently in her twelfth year at an all-girls school. She is currently teaching Grade 8 Math, Grade 8 Digital Literacy and Grade 8 Investigative Research. Finally, Denise has a Bachelors degree in Mathematics and is currently in her fifth year at an all-girls school. She also has six years of experience teaching in a co-educational school. She is currently teaching Grade 10 Math, Grade 11 Functions and Grade 12 Data Management.

Procedure

Before conducting interviews with my participants, I performed a survey of the current literature on the topic of math anxiety. I first attempted to provide a definition of this anxiety that arose from the literature. Next, the causes of this anxiety in students were examined, with specific reference to female students since this is the focus of my study. The effects of math anxiety on students was also uncovered through the literature. Finally, I outlined specific strategies suggested by the literature that were shown to be effective in helping female students with math anxiety. My sources came from books written on the topic of math anxiety as well as articles written in scholarly journals.

Following the literature review, face-to-face interviews were conducted with all four participants. Each interview took 45-60 minutes. Face-to-face interviews are effective for data collection in my research because I was able to not only hear the answers provided by the participants but to see their emotional reactions while providing the answers. A semi-structured questioning technique was used based on the same set of questions (See Appendix B). These semi-structured interviews allowed me to ask follow-up questions in the case that clarification was needed or alternate topics were raised.

My interview questions were grouped into the following themes: educational background, beliefs about math anxiety, practices in the classroom, influencing factors and next steps. These
themes were created based on themes that arose from the literature review and were also selected to directly address my research question and sub questions. I began by gaining an understanding of my participant's educational background and how she came to be a math teacher. I then questioned their understanding of math anxiety as it aligns with current research. Several more questions addressed the participant's beliefs about math anxiety. The next section of questions involved investigating teacher practices related to math anxiety. Here, I aimed to uncover whether or not the participants used explicit strategies in the classroom that they felt helped students with math anxiety and in what ways they were able to assess this effectiveness. I also asked my participants about the influencing factors involved in helping students with math anxiety. Finally, I investigated the next steps in this area that the participants felt were necessary. These questions included potential opportunities for professional development and advice for future math teachers. At the end of the structured interview questions, I provided my participants with the opportunity to provide opinions or insight on a topic that may or may not have been addressed in my questioning.

Data Collection and Analysis

I transcribed the interviews verbatim. These transcripts were kept private on my personal computer. The data collected from these interviews were then examined for common themes and related back to the themes outlined in the major review of literature in the field. This was achieved by reading each interview thoroughly three times and looking for recurring themes. I then performed a cross comparison of the four interviews to uncover common themes. This involved organizing key phrases from the responses to the same questions in a separate document. These responses were then examined carefully for common themes, as well as for themes that overlapped with the literature, and highlighted with different colours accordingly.
Once these themes were identified, the key phrases were organized underneath each theme, with careful association to each participant. The findings chapter was then organized around these themes with links between each participant's responses. Multiple readings of the interviews and the literature were necessary for this in-depth analysis.

**Ethical Review Procedures**

Well before their formal interview, I provided my participants with information about the research process that would be given to them in the letter of consent on the day of the interview. I clarified any questions my participants had by email before the interview. Two of the interviews were conducted at the participants' respective schools at a time agreed upon by both myself and the participant. One of the interviews was conducted in the participant's home and one of the interviews took place via an online video chat. Before their respective interviews, I provided each participant with a paper copy of consent form. Participants were required to read and sign the form before continuing with the formal interview process (See Appendix A). In the case of the online interview, the participant was emailed the consent form, which she signed, scanned and emailed to me before the interview took place.

Any questions the participants had at that time, or at any time throughout the interview, were addressed immediately. Participants were told that they would be kept anonymous throughout the research process and referred to by a pseudonym. Each interview was recorded using a digital recording device. Once the interviews were transcribed, they were sent to each of the respective participants. The participants were given the option to read over the transcript and to add, remove or clarify any point that was said. The participants were also told that they would be informed when the research program was completed and could request a copy of the final report if they so desired.
Limitations

Given the time allotted to this research study, findings may not be as in-depth as they could have been. With more time, a careful long-term observation of their classrooms would have taken place and could have provided a more comprehensive picture of their strategies to combat math anxiety. Participants could also participate in more than one interview, spaced over the observation period. Despite this lack of time, the interview participants and interview questions were carefully selected to provide maximal data to address the research question.

Another limitation with the research relates to the number of participants (n = 4). Furthermore, all participants were female. Within the scope of this research project, four participants were already more than the required two. However, two of the participants are affiliated with the same academic institution and all four participants are part of the same conference of schools. A more comprehensive list of strategies could have emerged with a larger group of participants, both male and female. Despite the small sample size, having observed two of the participants in their classrooms and being referred to the other two participants as a result of their expertise on this topic, the information provided by the four teachers created a relatively in-depth understanding of this issue in all-girls schools.

Finally, within the constraints of this study, the student voice about their own experience of math anxiety was not incorporated. Further studies could combine interviews with teachers with classroom observation as well as interviews with math-anxious students. The beliefs about math anxiety and the strategies used in the classroom given by the teacher participants were still very useful since all participants are experienced math teachers with a strong awareness of student math anxiety.
Chapter 4 Findings

The transcripts of the interviews with Theresa, Eliya, Janet and Denise were analyzed for common themes as well as themes from the literature review. It is important to note that although these themes are divided into subsections, there is some overlap between these sections.

Awareness of Math Anxiety

Although each participant has a slightly different way of defining math anxiety, they all understand that it is related to a general feeling of fear related to performing in math. Theresa strongly believes that math anxiety is a physiological response to a fear that develops as a result of a variety of factors surrounding situations in math. Janet's definition, on the other hand, stems from the psychological part of anxiety, where the feeling of fear actually leads to impairment in the ability to complete a task. Similarly, Eliya explains that it comes from a fear of not being able to perform and a fear of being wrong. Finally, Denise believes that math anxiety is a conscious or subconscious unwillingness to perform a task as a result of a generalized feeling of fear. Finally, all participants express that they have formerly and are currently working with math-anxious female students.

Causes of Math Anxiety

In addition to the awareness of the prevalence of math anxiety in their classrooms, the participants were all able to provide several potential causes for this anxiety. These causes can be grouped under the following themes: parental influences, school influences, societal influences and school influences.

Family influences.

All four participants speak of how parental attitude about math can contribute to a female
student's math anxiety. This negative attitude towards mathematics may be commonly accepted in homes and can translate into the attitudes of the students in the classroom. Janet explains,

...the origin I think also comes from, as sad as this is to say, it's from mother to daughter. I cannot tell you the number of times, honestly it is probably now nudging up to many hundreds, you know, five probably, five hundred I'd guess, moms who have said to me, 'Oh, well I haven't been good at math'. And I know, by the way it's said, is that's not the first time that mom has said it. So that is, it is acceptable, it is understandable, that is the way it is.

Echoing this sentiment, Denise says,

I think some of them hear at home, their parents say 'I was never good at math' so then they instantly start thinking that too and they just put in in their minds that they can't do something mathematically.

Theresa and Eliya also speak about experiences with parents influencing their child's attitude in mathematics, further supporting that this is an evident cause of math anxiety according to the participants.

**School influences.**

Both Theresa and Eliya highlight the nature of math to be a factor that contributes to math anxiety. They feel that students are not able to grasp the abstract side of mathematical content and find it difficult to relate to the concepts studied. Theresa explains,

I think math has a way of challenging people, it's a very, there's a lot of abstraction in math. The whole curriculum is highly abstract and it is not where kids' brains are at in Grade 7.

Eliya also expresses that this abstraction relates to the lack of background understanding that students have about the math they are learning. She believes that this results in a total disconnect from the material which can be a source of anxiety especially for females students.

Another point about the nature of math is its quantifiable nature, where students can feel that their ability in math is reflective of their abilities as an individual. Janet explains that this
part of math is “so different from most other disciplines.” Theresa believes that this self-reflective nature of mathematics can affect the students emotionally, especially when they have difficulty understanding more challenging and abstract concepts. She explains,

For some reason, math is highly emotional. [...] math has a way of getting at a kid's confidence like no other subject. Science is close, but math is fundamental. I mean I have seen kids and adults that felt traumatized by taking math.

All four participants speak about the how negative past experiences in the math classroom can contribute to math anxiety in female students. Theresa believes that some teachers exhibit negative attitudes towards students' abilities in the math classroom. These attitudes can in turn increase the anxiety of the students. She explains, “I've heard teachers say, 'If you don't know this by now, you're never going to know it' ”. She goes on to further explain that the anxiety can also come from the inability to connect emotionally or intellectually with the teacher, especially during the middle school years.

Similarly, Eliya explains that the way teachers have assessed students in the past, by giving tests and focusing on the answer being either right or wrong, can also have a negative effect on the female students' perception of mathematics. Finally, Janet believes that the way students have been taught math in the past can contribute to their anxiety. She says,

...certainly classically we didn't teach mathematics where there was collaboration, we didn’t teach mathematics where there was discussion, we didn't teach mathematics where we've pondered a big idea, we taught mathematics by learning skill. So that's one area I see is a problem.

Overall, the participants present strong beliefs that the school environment can have an impact on a female student's anxiety in mathematics. Having an awareness of this negative influence that can take place at school, the participants are very careful to not further intensify this anxiety in their students.
Internal influences.

The participants speak about female students who feel that their inability to succeed in mathematics is engrained in their personality. This general acceptance can be influenced by parents and culture, as previously mentioned, and is believed by the participants to be related to math anxiety. Theresa directly references the work of Carol Dweck (2006) which speaks about self-perception relating to the fixed mindset and the growth mindset. Theresa explains,

Girls in particular are very vulnerable to the effects of having a fixed mindset. Because when you have a fixed mindset and you come up against something that is challenging or difficult, the response is to denigrate themselves, denigrate their intelligence. 'Oh I must be stupid I find this difficult, I must be dumb, I'm dumb.'

Eliya, although not referring to mindsets, speaks from a similar perspective, saying,

...for some kids I think it's just part of their personality that no matter how many times you tell them that they are doing a good job and their improving and that they're going to get it right, there's something about... that's like engrained in her that she needs to be on all the time to make sure that it's right or something is going to go wrong.

Both participants outline that this negative self-perception can lead to a fear of failure and therefore a feeling of anxiety. Furthermore, Janet speaks about the influence that perfectionism, closely related to self-perception, can have on female students. She explains that,

...this is quite a significant concern for women, this need to be perfect. And so because they are so often able to quantify themselves mathematically and say that they aren't going to be perfect, or they often will make a mistake.

Similarly, Denise also recognizes the pressure for female students to be perfect. She says,

I think with...having worked with the females here, I can see that they always want to...they want to please, like a lot of the students here. So they get upset when they can't do something and they worry that opinions are being formed about them when there's a challenge that they have that they can't work through right away.

Overall, the participants believe that the self-perception of female students in
mathematics as well as their desire to be perfect could contribute factor to their anxiety in mathematics. An awareness of the causes of math anxiety in female students also relates to the understanding that this anxiety manifests in various ways in the classroom. The effects of math anxiety are discussed below.

**Societal influences.**

Eliya, Janet and Denise speak about the influences that society can have on the anxiety of their students in math. One issue arises from the general acceptance of math as a difficult subject. Eliya explains, “I guess there is a freely, like open acceptance of mathematical illiteracy, that, you know, there is, you know, especially with girls. That it's okay that you don’t get it, because this is really hard.” Denise also speaks about the general public opinion that math is a difficult subject and the acceptance that math is a difficult feat for most people.

Another issue that was discussed at length by one of the participants was that of the influence that gender stereotypes can have on female students. Janet, who also believes that there is a general acceptance of mathematical illiteracy, adds that this seems to be particularly influential for females. She expresses a similar sentiment when stating,

...very young women, the age of my children, are already directed culturally and academically to perform and be in classrooms in different ways. We encourage boys to take risks all the time, boys are naturally risk takers in many ways physically. And we encourage that, or we at least, we accept it as part of who they are and what they are. Whereas we don't do that with women. [...] But I watch the way they view mathematics and risk-taking and the other kind of behaviours I know will lead to success in mathematics.

Janet later provides more specific examples of stereotypes that exist in our society with respect to females and mathematics. She says,

...That Transformers can be taken apart and put back together in five different ways. We want proofs that go in fifteen different ways, we don't want bikes to all look exactly the same. What does it mean in fashion, and I worry about that. And
we can pretend that it's not just, that isn't just about math, but that math is one part of this whole big thing. And also that it's so important because we'll have a bunch of girls that don't know how to do stuff that we really need them to do in the culture. We need women to be able to understand and to take apart and put together something.

Clearly Janet feels very strongly that for female students to feel confident in mathematics, there needs to be an overall shift in the way females and males are viewed in society, beginning as early as childhood.

**Effects of Math Anxiety**

A common theme that came out of all four interviews relating to the effects of math anxiety involves avoidance. This avoidance can take form in a lack of participation, a tendency to withdraw or an unwillingness to try. Theresa believes “...that it prevents them from participating at times. Even girls who do participate will preface their answer with 'Um, this is probably wrong but...', 'I might be wrong...'”. Similarly, Denise expresses, “…there's the ones who will just completely withdraw and not want to stand out, hopefully just go unnoticed.”

The participants also explain that female students with math anxiety tend to exhibit a lack of confidence in the classroom. Eliya gives an example of a student who exhibits a lack of confidence in math, demonstrated by her use of language. Eliya explains, “There's this one girl in my class right now who every time, like she just gave me back this quiz and she like handed it to me and said 'I know I got #3 and #4 wrong'.”

Both Janet and Denise state that the apparent lack of confidence in their students' abilities is shown through the incessant posing of questions in the classroom. Denise explains,

And then some of them will just...then they have the opposite, so some of them will actually try to stand out, like ask a billion questions, ask the same questions like 5, 6 times because they're...they just want to make sure, want to make sure, and they want the assurance.
Clearly, the lack of confidence that results from the anxiety experienced by female students is evident in the participants' classrooms. Through identifying students as math-anxious, due to their avoidance or their decreased confidence, the participants are able to then implement strategies to help them in the classroom.

**Strategies for Reducing Math Anxiety in the Classroom**

Each participant employs many different strategies in their classrooms to help math-anxious students. These strategies are grouped under themes and, Chapter 5, connected to the literature.

**Identification and understanding.**

Since all of my participants are very aware of the issue of math anxiety in their classrooms, they all see value in the ability to identify this anxiety in their students. Of the four participants, Janet is the only teacher to actively use an instructional strategy to illicit student response and feelings about mathematics. She uses journaling early in the course to help her identify how her students are feeling about mathematics. She also consults her students individually on a regular basis and asks the students to complete self-evaluations throughout the course. Informally, Janet also identifies math-anxious students through their language in class or is directly told by the child's parent.

Although only Janet uses formal methods of identifying female students in math anxiety, all four participants do identify the issue by informal means. Both Theresa and Denise explain that they identify the anxiety by the students' language. Theresa explains,

So informally, I identify it with the kinds of things they say in class. There are certain triggers for me that make me think okay, she sounds quite anxious and then before test time, I can see again it's what the students say to me that helps me identify. It's their language.
Denise expresses a similar observation about the language used by the students. She says,

Some of them will actually open up and share that information. So that makes it easier to identify. So right from the start of the year, some of them who came up to me and said, 'I'm a little be nervous about how this course is going to go.'

As a first step to helping students with mathematics anxiety, identification and understanding becomes essential for all teachers. Once the math-anxious student is identified, the participants employ many other strategies to help her in the classroom.

**Student and teacher language.**

Three of my participants explained that a strategy they use in their classroom to help students with math anxiety involves modeling and teaching the students to use positive and constructive language. Theresa explains,

I pay very close attention to the language that I use and I try to emphasize the learning and I also have a talk with...so that's my own thing, I take responsibility for that and then I ask the girls to use that kind of language as well. […] I don’t even say incorrect or correct, like I just...I avoid that language completely […] 'I'm so confused' I don’t let them say that. I tell them they need to shift their language to say 'I need to figure this out' because being confused is an endpoint, it is a state. I don’t know how to help you with that. If you need to figure it out, I can help you figure something out.

Denise and Janet also try to use language that is encouraging and try to emphasize that mistakes are just a part of the learning process. They both feel that a shift in the language used by both the teacher and the student can help foster more positive perceptions of math.

**Building positive teacher-student relationships.**

All participants emphasize the importance of building positive relationships with students to help them alleviate their anxiety in mathematics. Theresa explains that “...having an actual relationship with the teacher is so important for girls, especially at the Grade 7/8 age. They need to feel cared for, they need to feel that they can trust me.” Janet echoes this point by saying,
“One of the best ways for women is to build around relationships, whether that's innate I don't know. But it's certainly what's true here, it's what's true with women that I know.”

Eliya also believes that one of the most important ways to decrease math anxiety is to build relationships with students and to keep the learner at the centre of your priorities. She adds,

...their grades and their test scores and their standardized test scores and, getting to the end of the book or covering your curriculum is not the most important thing. Their comfort and their enjoyment and their desire to learn and fulfillment in the classroom is what should always be paramount. And that's the hard thing to do when you're a teacher.

Speaking on the topic of building relationships, Denise also gives an example of a student with whom she worked, who was experiencing severe math anxiety. As a means of helping this student, she first tried to establish a strong rapport her. As a result, this specific student was willing to open up and seek help from Denise. She also gives the following advice to beginning teachers,

...be encouraging, do it consistently. Get to know your students as well as you can because each student is different. […] It does require a lot of individual attention and staying on top of that through the whole year. And basically not giving up on those students.

Clearly, the participants believe that an effective strategy for helping the math-anxious female student involves getting to know the student and building a relationship with them in the classroom. This can be achieved in many way and is essential for female students to develop a more positive feeling towards mathematics.

**Talking with students individually.**

Three of the participants hold that it is very important to speak regularly with individual students about their progress in the math classroom. This can provide a lot of information to the
teacher and can allow the student to feel more valued in the classroom. Speaking with students individually also contributes to building a positive relationship with them.

One of Theresa's main strategies in helping students with math anxiety involves debriefing with each student individual after a test. In this way, she is able to be specific with the students about their target area of focus and to help them improve for the next time. She believes that this allows the students to feel less anxious because she is able to give them specific areas for improvement.

Janet also uses one-on-one conferencing with students to talk about the lessons that they teach in the classroom. She believes that this allows the students to express how they felt about their lesson as well as discuss areas of strengths and areas for further development. She explains that the anxiety they have around mathematical concepts can decrease as they become more comfortable teaching their peers.

**Collaborative learning.**

Three of the four participants use collaborative learning to help female students with math anxiety. Eliya explains that she uses partner problem-sets since she has seen that girls find the math more enjoyable when they collaborate with a partner. She has seen from her experience that girls like to collaborate more than boys and it can build confidence by receiving feedback from their peers.

Collaboration in Janet's classroom involves requiring the students to teach certain topics to the entire class throughout the year. She says “.they understand that they are going to have to teach in front of their peers or run the class, so that the class is in discussion or collaborative learning.”
Theresa, on the other hand, believes that although collaborative learning is very important, female students still do need to learn how to work independently. She holds that in learning to work independently, the students can also learn how to manage the anxiety they may face.

**Allowing students to feel connected to the math.**

Theresa, Eliya and Denise all speak about decreasing student math anxiety through allowing students to feel that they can really relate to what they are learning in the math classroom. According to the participants, this can be achieved in many ways including providing the students with opportunities to achieve deep understanding of the math, using problem-based learning and providing examples of math that apply to the real world.

Theresa explains that the enjoyment for female students comes from the deep understanding of the mathematics. She believes that,

...the fun, the enjoyment, comes from learning the math, learning it in depth and then really understanding why you're doing what you're doing at each step of the solution. There's a sense of accomplishment that's fulfilling. I want math to be fulfilling not fun.

Eliya speaks about the use of Problem Based Learning in the classroom, where she allows her students to discover how to solve problems in math instead of being told how to by the teacher. She has found that can help to identify and to alleviate anxiety in math by allowing the students to feel “connected to the material”. She also believes that anxiety can be lessened since the students are constructing their own knowledge and taking control of their learning.

In order to allow her students to feel connected to the subject matter, Denise tries to link the math as much as she can to the students' lives by incorporating examples that they can relate
to and by incorporating their interests in the classroom. She believes that this can allow them to “see a more of an enjoyable side of the subject,” and therefore feel less anxious in general.

**Encouraging risks and building on mistakes.**

Janet and Denise both emphasize the value of teaching female students that taking risks and making mistakes can help them improve in math. Janet believes that boys are generally more likely to take risks inside and outside of the classroom. She explains,

...young girls, they're expected to be pretty, they're expected to be good. Those are great words, I think, to use in this idea. And mathematics is often not pretty, it can be beautiful, but it is not clean always and we are going to make mistakes and taking a risk is going to be about taking mistakes.

Janet uses a previously mentioned strategy, teaching in front of their peers, to help her female students learn to take risks in the classroom and learn from their mistakes. Similarly, Denise believes that female students can be less anxious in math if they are able to take risks and feel open to make mistakes. She says,

I always try to say things like 'It's normal to make mistakes along the way, so make those mistakes and learn from them, just give it a try you do not have to get it right the first time'. So there's a lot of trying to encourage them to take risks and not be afraid to do that.

Overall, allowing female students to feel comfortable enough to take risks and make mistakes was recognized as a difficult task by the participants. It is believed, however, to be very helpful for female students with math anxiety.

**Partnering with other stakeholders.**

Another strategy that is used by the participants to support their students is that of seeking help from educational stakeholders such as parents, other teachers and guidance counselors. The participants express the belief that this can help ultimately female students with math anxiety. Theresa explains that stakeholders within her school are willing to collaborate on this topic, but
she feels that they may not be actually “helping girls learn how to manage anxiety in a way that's actually healthy and effective.” She expresses later that she wishes there would be professional development opportunities about mindfulness techniques that could support her in her effort to help female students deal with math anxiety.

Both Denise and Eliya believe that information from other colleagues can assist in the effort to work with math-anxious female students. They explain that their colleagues could share their experiences and different perspectives about the students. Denise says,

… other teachers may have students who have shown similar behaviours with math anxiety so they may have strategies that work for them. So there's a lot of communication that always has to happen, you just have to do it regularly to put together the best plan or strategies for that particular individual.

Partnering with stakeholders also involves providing extra help opportunities within the department and the school. Janet explains,

...we have things like extra help every day. And I think at the beginning when we started doing that, people were like 'Why do you need to have extra help everyday, couldn't you be working on improving program?' And I think it's now more understood that extra help isn't just extra help. It's that level of connectedness and comfort and relaxation.

Overall, the ability to teach and learn from other educational stakeholders about how to help students with math anxiety was believed to be very important by all participants. Ultimately, a whole-school effort is essential when learning how to help math-anxious female students.

**Use of technology.**

Denise feels strongly that math anxiety can be alleviated through the use of technology in the classroom. She explains that the fact that students are so comfortable with technological
devices means that they may feel less anxious about math that is performed using this technology. She says,

Definitely technology helps those students who have math anxiety. Especially now I think because students are so comfortable with technology in general, just because it's around them. They all have computers, they all have phones, they're pretty quick to pick up those skills. So I don't have to worry about them being nervous about technology.

**Use of relaxation techniques in the classroom.**

Theresa, who strongly believes that math anxiety has a great effect on the students physiologically, uses specific relaxation techniques with her students in the classroom. She explains,

I actually teach them a relaxation technique and we go through a little group relaxation right before the test [...]. And I explain to them how their bodies react to anxiety. [...] If you are freaking out for two days about your math test, then your ability to focus is actually compromised, your ability to recall information is compromised. So I’m well aware of the physical results of being in an anxiety state for a long period of time. So the way to deal with that is to manually switch them over to the relaxation branch through breathing.

Although Theresa was the only participant that uses relaxation techniques to help her students deal with math anxiety, she feels very strongly that it is a practice that all teachers should employ in their classrooms. Further research could explore the effectiveness of this strategy in the mathematics classroom.

**Teaching the growth mindset.**

Theresa is an advocate for Carol Dweck's (2006) on fixed mindset and growth mindset. As such, she believes in teaching her students about their brain and its ability to improve and develop. She has incorporated the curriculum 'Brainology' (Dweck, 2006) as a means to teach students about the growth mindset. Theresa says,
So I actually have been working on teaching a growth mindset. Because I think that if you believe that you are capable of learning and that a challenge is...moving through a challenge is the way you learn then that will, I believe, reduce anxiety. Because then you’re not afraid that you won't be able to do it.

Assessing the Effectiveness of the Strategies

Each participant comments on the feedback they receive from the students that allows them to understand which strategies are effective. Theresa says,

Kids actually come to like math, you know? And they talk about how ...math becomes their favourite class, you know? And I believe it's not because I'm the most amazing pedagog in math, it's because they get what they need emotionally.

When referring to her use of relaxation techniques, Theresa adds “They tell me, 'Oh, I feel so much better now, I feel so much calmer.' And I ask them, 'Are you able to remember things better?' They said yes.”

Theresa also provides an example of a student who was experiencing serious math anxiety in her classroom. Theresa spent a lot of one on one time with her, communicating about what the problems were and allowing to feel emotionally and academically supported. She began to participate more in class and make more effort in her learning. The effectiveness of her strategies was demonstrated through the fact that the student went from failing to getting a mark in the mid-eighties.

Janet also believes that the strategies she uses to help her students are effective. Since one of Janet's main strategies involves having her students teach portions of the class, she knows this is effective since the students come back the following year and say “I really miss teaching!”

Overall, each participant strongly believes that the strategies they implement in their classroom are effective in reducing math anxiety in their students. Although the effectiveness of
the strategies are not assessed formally, the observations and opinions of these experienced teachers provide strong evidence of their validity.

Challenges

Despite their best efforts to help math-anxious students, the participants were vocal about challenges they have encountered in this effort. These challenges can be grouped under the following two categories: school climate and curriculum.

School climate.

Two of the participants express the challenges that the school climate can pose when they are making efforts to help their female students in mathematics. Theresa speaks of the difficulties she faces with the overall busyness of her school and the lack of time she has to collaborate with other colleagues in the effort to help the students with their anxiety. Janet echoes this sentiment by explaining that her math program moves at a very fast pace, and that extra-curricular involvement on the part of the student and the teacher can make it very difficult to find time to effectively put strategies in place.

Curriculum.

Meeting the demands of the math curriculum is another common challenge for the participants. Theresa explains that the curriculum does not allow her to spend a lot of time focusing on non-academic efforts with her students. She says,

...you have this whole sort of prescribed curriculum and you have to meet these goals. You have to have this covered by this point […] And when you take that approach, where's the room for stopping to address the needs of...the emotional needs of the child?

Eliya also finds the curriculum presents challenges in her effort to help her students, mainly due to the focus of the material. She explains,
So the curriculum itself is, you know, it's like a time bomb of anxiety for them. And not just for girls, for all kids who have weakness in math, you know. And it's just it's really sad. We could do a lot to change the math that their learning to focus more on modeling and statistics and understanding and interpreting data, learning about the math of global warming, or anything like that, that would actually make a difference in their lives right now. [...] So I just think that there's a lot that the curriculum focuses on that is irrelevant to them.

Overall, Theresa and Eliya feel that there are challenges that arise from the mathematics curriculum. Despite these challenges that are faced by many teachers, they continue to make much effort to help their female students.

**Professional Development on Math Anxiety**

All four participants express the desire for professional development opportunities on the topic of math anxiety. Although each participant has a slightly different take on the focus of the professional development, each involves gaining more insight into how they can help their students.

Theresa wants professional development specifically on mindfulness techniques that she can teach her students. This would involve teaching the children about their physiological responses to anxiety and allow them to learn how to mitigate the bodily effects. Eliya, on the other hand, seeks to understand more deeply where female students place the blame for their anxiety. She also believes that professional development can be improperly directed in schools and that strategies for helping students deal with math anxiety may be better taught in teacher education programs. She explains,

I would think it would focus on, what would you call it, like breaking down the belief systems that girls have about math as a subject and beliefs that they may have about themselves and the subject. And the ways that teachers can help themselves help the students to kind of deal with the anxiety.
Janet wishes professional development could happen in the area of learning how to formally assess the pervasiveness of the problem of math anxiety among female students. Like Eliya, she feels that in-school professional development is not always very effective. She explains, however, that it would be beneficial to watch and analyze videos of students in order to learn how to explicitly work with them on their anxiety.

Finally, Denise expresses the desire to understand more about the specific classifications of math anxiety. The professional development, in her opinion, would therefore focus on these classifications and teach specific strategies that apply to each classification. She also wishes to be given the time to share and discuss issues surrounding math anxiety with other colleagues.
Chapter 5 Discussion

My research on the topic of math anxiety in female students has provided me with new understanding and insight in ways to better educate female students in mathematics. As a result of my study, teacher beliefs about math anxiety as well as strategies to help students have been highlighted and provide practical advice for myself and other math educators alike. This advice can be implemented in the math classroom. This chapter therefore discusses the connections between my findings and the literature as well as implications for current and future mathematics teachers. I also revisit some of the limitations and discuss areas for further research.

Connections to Literature Review

In comparing the literature review to the findings from the data collection, the participants echoed many of the main themes which emerged from the literature. It was therefore evident that the participants were very aware of the issue of math anxiety in female students as well as the best practices to help their students in the math classroom.

**Awareness of math anxiety.**

Each participant provided a detailed definition of math anxiety which made it clear that this was an issue they were continually facing with their female students. According to Tobias (1993), it is crucial for educators to understand what math anxiety is and how it can be recognized in the classroom. Furthermore, an awareness of the origin of this anxiety and how it manifests in students becomes essential in the effort to ultimately help these students (Furner & Duffy, 2002). Not only did the participants express an awareness of the prevalence of mathematics anxiety, but they also demonstrated a thorough understanding of the causes and effects of this anxiety in female students.


Causes of math anxiety.

The literature and the research findings very closely echo each other with respect to the causes of math anxiety. The themes that arose from the findings overlap with four out of the give themes from the literature review.

Family influences.

All participants speak in detail about their belief that parental attitude can directly affect the female student's attitude in mathematics. This factor seemed to emerge as one of the primary contributors to math anxiety according to the participants. Janet and Denise specifically refer to the attitude of mothers directly influencing their daughters. The literature supports this claim, explaining that parents can influence their daughter's feelings about mathematics through exhibiting a negative attitude about the subject or through holding traditional perceptions about their daughter in mathematics (Zaslavsky, 1994).

School influences.

School influences were also discussed at length in the literature and by the participants. Theresa speak about how a negative attitude by the teacher towards mathematics can increase the anxiety of students in mathematics. Jackson & Leffingwell (1999) echo this sentiment in stating that negative attitude, among other practices in the classroom, can intensify student math anxiety.

Another topic discussed in both the literature and by the participants was that of the nature of the math curriculum. Tobias (1993) explains that teaching math in discrete parts with little connection to students' lives can contribute to their math anxiety. Furthermore, a focus on memorization of concepts can lead to only superficial understanding and a decrease in confidence in mathematics (Steele & Arth, 1998). Similarly, both Eliya and Theresa believe that math anxiety results from the abstract nature of many mathematical concepts that can ultimately
lead to a disconnect from the material. Eliya further explains that this inapplicability of mathematics to real life can be anxiety-inducing especially for females.

Teachers who experience math anxiety can perpetuate this anxiety in the math classroom (Geist, 2010). More specifically, female teachers' math anxiety can have a direct and negative effect on achievement in mathematics by female students (Beilock et al., 2010). None of the participants, however, feel that they experience math anxiety. I was therefore unable to draw any parallels about the effect of teacher math anxiety based on my research. This could have been a result of their strong background in mathematics, an issue which could be further researched.

**Internal influences.**

All participants speak about self-perception in mathematics relating to the experience of math anxiety in female students. Since females tend to attribute their academic failures to their intelligence, this can result in higher levels of anxiety in mathematics (Pajares & Graham, 1999; Tobias, 1993). Both Theresa and Eliya specifically highlight experiences with math-anxious students being anxious as a result of believing that they are not adept in mathematics. Moreover, Janet and Denise express their belief that perfectionism, which is closely related to self-perception, can also contribute to female math anxiety.

Finally, Theresa directly references the work of Carol Dweck (2006) by stating her belief that females who perceive themselves as having a fixed mindset can experience anxiety in mathematics. Although I was unable find literature that directly linked mindsets to the experience of math anxiety, Theresa's strong belief of the connection between the two could mean that the potential correlation would be an area of interest for future research.

**Societal influences.**

Societal perceptions of mathematics were provided by the participants as a potential
cause of female math anxiety. Eliya and Denise both express their belief that some female students develop a negative perception of mathematics due to messages received from society at large. Furthermore, Janet highlights gender stereotypes in society that she believes contribute to female math anxiety, specifically with respect to popular toys for children. Zaslavsky (1994) explains that these gender stereotypes can contribute to a lack of confidence for females in mathematics.

**Neurological considerations.**

An area of discussion that emerged from the literature but not from the interviews was that of the neurological considerations of math anxiety. There are two possible explanations for this discrepancy. Either the participants are not aware of a neurological factor that can contribute to math anxiety or they were operating under the assumption that this study focused on students without neurological differences or impairments.

**Effects of math anxiety.**

With respect to the perceived effects of math anxiety by the participants, there were also many overlaps with the literature. Firstly, it is clear that math anxiety can result in instances of avoidance in female students. Both Eliya and Denise give examples of female students who tend to avoid participating in class and prefer to go unnoticed. This connects closely with the literature where Tobias (1993) states that there tends to be a higher level of avoidance in females in math during the middle school years, compared to males of the same age.

Secondly, the participants speak about a general lack of self-confidence and a poor attitude relating to math anxiety. This lack of confidence is perceived by the participants through the language used by the students in the classroom. The decrease in confidence as a result of math anxiety is also echoed by Tobias (1993) and Ashcraft (2002) in the literature. Moreover,
through examining the literature and in the findings, it became unclear whether a lack of confidence and a negative self-perception is in fact a cause of math anxiety or an effect of math anxiety. This could demonstrate that self-perception, confidence and anxiety are so closely related that it becomes very difficult to tell which is the root cause. In fact, Ashcraft (2002) actually incorporates lack of confidence into his definition of math anxiety.

Finally, the topic of affective drop in performance (Ashcraft & Moore, 2009), however, was not mentioned in the interviews. This could have been due to the fact that timed assessment tasks were not directly addressed in the interview questions. With further questioning on this topic, the participants may have been able to speak about this potential drop in performance.

**Strategies for teachers.**

Both the literature and the participants provide many practical strategies to help female students with math anxiety in the classroom. Many of the strategies overlap between the literature and the data from the participants' interviews. A comprehensive list can be found on pages 57-58.

**Identification and understanding.**

The literature emphasizes that identification and diagnosis is the first step in helping students overcome their math anxiety (Tobias, 1993). All four participants actively seek to identify which female students in their class may experience this anxiety. This identification process is mostly informal and involves student language and general attitude in the classroom. Formally, Janet is able to identify math-anxious students through reflection journals in mathematics. According Furner and Duffy (2002), journaling can also be used as a strategy to help students deal with math anxiety in the classroom.

Although there are explicit tests that can be used to identify math anxiety in students,
such as Richardson and Sunni’s (1972) MARS, none of the participants have employed these types of tests in the classroom. Further research could explore math anxiety as experienced by female students in all-girls schools using these types of tests for math anxiety.

**Collaborative learning.**

All participants value collaborative learning as a strategy to help female students with math anxiety. Eliya frequently uses partner problem sets which she has found to be particularly effective in engaging her female students. Janet's collaborative learning techniques involve her students teaching parts of the curriculum and engaging in discussion with peers about these topics. Lavasani and Khandan (2011) and Powel and Enright (1990) express that collaborative learning can lesson anxiety by allowing students to increase their confidence through receiving feedback from their peers. The participants echo the literature saying that collaborative learning can be effective in lessening anxiety especially in female students as a result of a decrease in classroom competition (Batton, 2010; Johnson & Johnson, 1989).

**Creating a positive classroom environment.**

Another theme from the findings that was also supported by the literature involves creating a positive classroom environment. According to the literature, there are many ways to foster positivity in the classroom, including building relationships with students, incorporating their interests into the lessons and building on their prior knowledge (Furner & Duffy, 2002; Stuart, 2000). Building positive relationships with female students was a strategy that all participants felt was essential in helping female students with math anxiety. Another theme from the findings which relates to creating a positive classroom environment involves the use of encouraging and constructive language in the classroom. Both Theresa and Denise emphasize the importance of not only using this type of language themselves, while also encouraging their
students to adapt a similar language.

Encouraging risks and building on mistakes.

Both the literature and the participants emphasize the importance of teaching students to take risks and learn from their mistakes. According to Janet and Denise, these risks can take many forms which include teaching in front of other students and expressing solutions in different ways. Ultimately, risk-taking can lead to the understanding that making mistakes is a natural part of the learning process. Steele and Arth (1998) highlight that math-anxious students find it especially difficult to take risks in the classroom. It therefore becomes important to encourage multiple expressions of mathematical solutions which can ultimately support growth and increase confidence in students (Steele & Arth, 1998). Furthermore, once students understand that it is beneficial to make mistakes in the classroom, teachers can help them to build on their mistakes and progress to a deeper understanding of the subject matter (Stuart, 2000; Steele & Arth, 1998).

Allowing students to feel connected to the math.

Each participant employs strategies in their classrooms that involve connecting math to the students' lives. Theresa believes that the enjoyment in math for girls comes from the deep understanding of the material. Eliya and Denise also both express the importance of allowing the students to feel connected to the material, either through the construction of knowledge on their own through problem based learning or through presenting situations in math that can apply to the real world. Stuart (2000) supports this strategy by explaining that students must see a purpose to the math they are learning in order to feel a positive connection to it.

Providing regular feedback to students.

Both the literature and the findings support the use of regular feedback as a means of
mitigating anxiety in female students. Both Theresa and Janet regularly debrief with their students after assessments in order to support further growth and development and to allow their students to share their opinions. This strategy is supported in the literature by Stuart (2000) who states that allowing students to have a voice in their learning can increase their sense of worth in the classroom. Furthermore, providing formative assessment opportunities has been shown to increase self-efficacy and therefore decrease anxiety (Brookhart et al., 2008).

**Use of technology.**

Denise speaks about her belief that technology can help alleviate math anxiety in female students. The literature also holds that technology can be used reduce anxiety by allowing students to visualize math in a different way, while also giving students the opportunity to perform mathematical investigation which can foster excitement in math (Ashcraft, 2002; Furner & Duffy, 2002).

**Other strategies.**

Several strategies were presented in the literature that were not directly addressed in the findings. These include: integrating students' emotions into the math classroom (Furner & Duffy, 2002; Tobias, 1993), differentiating instruction to accommodate for different learning styles and foster confidence in math (Geist, 2010; Landrum & McDuffie, 2010; Tomlinson, 1999; Wadlington & Wadlington, 2008) and reflecting regularly on practice (Furner & Duffy, 2002; Woolfolk et al., 2010). Although not covered by the participants, these strategies are worth mentioning since research has demonstrated their effectiveness in helping students mitigate their math anxiety. With more time, multiple interviews with participants and observations of their classrooms, more of these strategies may have been addressed.

There were also several strategies outlined in the interviews that were not evident in the
literature review for this study. These include partnering with other stakeholders in the effort to help math-anxious female students, incorporating relaxation techniques into the math classroom and teaching students about their brain through Carol Dweck's (2006) *Brainology* curriculum. The participants who speak about these strategies feel they are effective and are therefore. Further research on the topic of math anxiety in female students may support these strategies in the literature.

**Effectiveness of strategies.**

All participants speak about the belief that the strategies they use to help students with math anxiety. None of the participants, however, have measured the effectiveness of these strategies explicitly through the use of math anxiety rating scales. Several of the strategies suggested in the literature have been tested formally for effectiveness using various means such as the MARS (Richardson & Suinn, 1972). Despite the lack of formal means to test effectiveness, the these findings are still very valid since all participants are experienced and exemplary math educators.

**Implications for the Current and Future Teacher**

The findings from the literature and the interviews with participants suggest that student math anxiety is an evident issue in all-girls schools. The responses from teachers in all-girls schools who are actively working to help their students with math anxiety can provide current and future teachers with practical and effective strategies for the classroom. Many of the topics discussed were also validated by the many connections to the current literature on math anxiety.

Regarding the causes of math anxiety that emerged from the participants responses, a few implications become evident. Since parental attitude seems to have a significant impact on their daughter's self-perception in mathematics, parents need to be educated about how to prevent this
influence on their daughter. This could take form of formal or informal information sessions for parents to educate them about how math anxiety can develop in female students.

Societal influences surrounding females in math is another issue that educators need to be made aware of when teaching female students. Since there still exist stereotypes in our society that support old traditions (erg. Tobias, 1993; Zaslavsky, 1994), educators need to teach their female students to challenge these stereotypes and to succeed in mathematics regardless of the messages they may see in society.

Another principal cause outlined by the participants was that of the nature of math and past school experiences. Although educators cannot prevent negative past experiences from happening to their students, they can take control of what happens in their own classrooms. Perhaps what teachers, school administrators and curriculum designers alike could learn from this study is that there may need to be a shift in how math is taught in schools. One of the major strategies that the participants are currently using, which is also supported in the literature, involves teaching the current curriculum while making it connect with the students' lives. With an understanding of how mathematics can be useful and applicable to real life, students may become more enthusiastic and less anxious about mathematics.

Since many of the causes of math anxiety may not be preventable by the teacher alone, building relationships with students and creating a positive classroom environment become essential. Several strategies suggested by the participants which contribute to the positive classroom environment include the use of encouraging language, speaking with students individually about progress, adapting collaborative learning techniques and allowing the students to have a voice in their learning. By acting as a positive role model in mathematics, educators can help their students cope with the anxiety they may have developed in the past.
The findings on the effects of math anxiety also have several implications for all teachers. If a student is experiencing math anxiety in the classroom, there will be several ways a teacher can identify this problem. Since all participants and the literature review outline the importance identifying math-anxious students, this needs to be recognized by all educators as the first step in helping students with their anxiety. By understanding that math anxiety can result in behaviours such as lack of confidence in the classroom, avoidance, a lack of confidence and poor attitude, educators can take note of these instances and act to help their students.

Lastly, although this study focuses on math anxiety in all-girls schools, the prevalence of math anxiety extends beyond this environment to include co-educational classrooms and is experienced by both male and female students alike. By understanding the influence math anxiety can have on all students, this issue needs to be addressed in all schools through professional development as well as in pre-service education. Topics could include prevalence of the problem, the causes and effects of math anxiety, perceptions of students, ways to identify math-anxious students and effective strategies to help these students in the math classroom. Through a conscientious effort on the part of all educational stakeholders, the issue of math anxiety can be combated in all schools and could lead to an overall improvement of societal attitudes towards math.

List of Recommended Practices

There were many strategies provided both in the literature and by the participants to help female students with math anxiety. The following list provides a summary of these strategies for educators to implement in their practice.

- Know what math anxiety is and how to identify math-anxious students (Furner & Duffy, 2002; Tobias, 1993).

• Cultivate a positive classroom environment (Furner & Duffy, 2002; Stuart, 2000).

• Allow student to feel connected to the math (Stuart, 2000).

• Differentiate instruction to accommodate for different learning styles (Geist, 2010; Landrum & McDuffie, 2010; Tomlinson, 1999; Wadlington & Wadlington, 2008).

• Encourage multiple ways to solve a mathematical problem (Steele & Arth, 1998).

• Allow students to express emotion in the classroom (Furner & Duffy, 2002; Tobias, 1993).

• Build positive relationships with the students.

• Speak with students on an individual basis about their progress.

• Allow students to have a voice in their learning (Stuart, 2000).

• Provide regular feedback to students (Brookhart, Moss, & Long, 2008; Wadlington & Wadlington, 2008).

• Encourage risk-taking and building on mistakes (Steele & Arth, 1998; Stuart, 2000).

• Use language that focuses on the learning process and encourage students to use the same language.

• Teach relaxation techniques to alleviate the physiological responses to anxiety.

• Teach students about the brain development and the difference between the fixed and growth mindset (Dweck, 2006).

• Use technology in your instruction (Ashcraft, 2002; Furner & Duffy, 2002).

• Partner with other educational stakeholders.

• Regularly reflect on your own practice (Furner & Duffy, 2002; Stipek, 2002; Woolfolk, Winne, Perry, & Shapka, 2010).
Limitations and Areas for Further Study

Although this study could prove beneficial for pre-service and practicing teachers alike, there are still limitations that exist. As mentioned previously, the number of literature sources as well as the number of research participants were limited due to the time constraints of this research project. The research participants were also all female and a future study could benefit from studying the male teacher perspective on female math anxiety as well. Furthermore, this study focused on the perspectives of practicing teachers about the anxiety of their female students, rather than hearing directly from the students. A next step would be to speak directly with female students about their perceptions of math anxiety and unveil what they believe would help them in the math classroom. This study could also benefit from observation of female students in math classrooms in order to further understand the situations that arise from the experience of math anxiety.

In addition, future research could also be done to solidify the recommended best practices presented in this study. As previously mentioned, the effectiveness of the strategies provided in this study were only supported anecdotally. A longitudinal study, comparing the levels of math anxiety before and after the implementation of a program based on these recommended strategies in the classroom, and possibly using a rating scale such as the Math Anxiety Rating Scale (Richardson & Suinn, 1972), could dramatically highlight their effectiveness.

Theresa felt strongly that the use of relaxation techniques before assessments aided in the alleviation of math anxiety in her students. With the perception of math anxiety as a physiological manifestation, the use of relaxation techniques could prove effective in helping math-anxious students. Although none of the other participants nor the literature for this study mention this specific strategy, Theresa's enthusiasm and experience shows that further research
could demonstrate its effectiveness.

Since all of my participants teach at independent schools, their backgrounds in mathematics were quite extensive. Geist (2010) stated that teacher anxiety can have an affect on student anxiety in mathematics. Although none of my participants felt they had ever experienced math anxiety, this could have been a result of their strong educational backgrounds in mathematics. Therefore, another area for future study could examine whether there is a correlation between a teacher's educational background in mathematics and their experience with math anxiety. The results of this study could ultimately inform pre-service education entrance requirements to teach mathematics at the Intermediate-Senior level.

Conclusion

The issue of math anxiety and its effects on students has been of interest to me throughout my career as a math student and now as a beginning math teacher. Although this study specifically highlights the prevalence of math anxiety all-girls schools, this anxiety is also present in co-educational settings and even extends beyond the classroom to society at-large. It is clear that this problem needs to be addressed by all educational stakeholders in schools as well as in pre-service teacher education programs.

In order to help students who are dealing with math anxiety, current and future educators must first be knowledgeable about the causes and effects of this anxiety in the classroom. Furthermore, educators must understand that math anxiety can have a negative impact on the academic, mental and emotional well-being of students. With this awareness, it becomes inarguable that all educators must actively implement strategies to alleviate the math anxiety of their students and, ultimately, to support their success in the math classroom.
References


Appendix A: 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 purposes of investigating an educational topic for my Masters research component, I am looking at mathematics anxiety in female students in all-girls schools and the strategies teachers use in the classroom to mitigate this anxiety. I believe that your knowledge and experience will provide 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. Patrick Finnessey. My research supervisor is Limin Jao.

My data collection will consist of a 40 minute interview that will be audio-recorded. 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,

Megan Clark
(416) 258-6527
megan.clark@utoronto.ca

Instructor’s Name: Dr. Patrick Finnessey
Email address: pk.finnessey@utoronto.ca

Research Supervisor’s Name: Limin Jao
Email address: limin.jao@utoronto.ca
Teaching the Math-Anxious Female Student

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 _______________________ (name of researcher) and agree to participate in an interview for the purposes described.

Signature: ______________________________________

Name (printed): ___________________________________

Date: ______________________


Appendix B: Interview Questions

Section 1: Background Information

1. a. What is your educational background?
   b. How did you come to be a mathematics teacher?
   c. For how many years have you been teaching?
   d. Have you taught in both all-girls schools and co-educational schools?
   e. If so, how long in each?
   f. What grade(s)/subjects(s) are you currently teaching?
   g. What grade(s)/subjects(s) have you taught in the past?

Section 2: Beliefs

2. Could you begin by giving me a brief definition of the term “mathematics anxiety” as you understand it? (math fear, math phobia, etc.)

3. Have you taught female students that experienced mathematics anxiety?

4. Do you feel that you have ever experienced mathematics anxiety as a student?

5. If so, how do you think it originated and how were you able to move past it?

6. From your experiences as a mathematics educator (and as someone who has potentially experienced mathematics anxiety), what do you believe to be some of the major causes of mathematics anxiety in female students?

7. From your experiences as a mathematics educator, in what ways does mathematics anxiety affect your students in the classroom?

8. Do you believe that female students in all-girls schools experience mathematics anxiety differently than female students in co-ed schools? If so, in what ways?

Section 3: Practices

9. How are you able to identify, formally or informally, the students in your classroom who may be experiencing mathematics anxiety?

10. Do you use explicit strategies to help female students who have mathematics anxiety?

11. What strategies do you use in your classroom that you feel help female students who are struggling with mathematics anxiety?

12. How are you able to assess the effectiveness of these strategies?
13. Can you tell me about 1 or 2 resources (e.g., books, websites, software, personnel, information from professional organizations) that you have used to enhance your classroom instruction that has been beneficial to math anxious students?

14. Have you seen positive outcomes of your efforts to help students with math anxiety?

15. If so, what were they?

16. Could you share with me a specific experience you have had with a female student who was dealing with mathematics anxiety and how you were able to help them?

**Section 4: Influencing Factors**

17. How do other educational stakeholders (e.g., students, parents, teaching colleagues, school administrators) help you continue or expand your ability to help students with mathematics anxiety?

18. What obstacles or challenges have you faced when helping students with mathematics anxiety?

19. Were you able to overcome these challenges? If so, how?

**Section 5: Next Steps and Advice to Future Teachers**

20. What would you still like to learn that would help you to better deal with female students experiencing mathematics anxiety?

21. Do you feel like training (professional development) on this issue would be advantageous to mathematics teachers?

22. If so, what do you think that training should focus on?

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

24. Would you like to share anything else that we have or have not covered?