

MATHEMATICS ANXIETY IN PRE-SERVICE ELEMENTARY TEACHERS

by

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A Thesis

Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Arts in School Psychology

at

Mount Saint Vincent University
Halifax, Nova Scotia

October 2009

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Abstract

This study explored the impact of mathematics methods courses, including practicum experiences, on the level of mathematics anxiety experienced by pre-service elementary teachers. Participants included 99 first and second year students completing a teacher education program at a university in Nova Scotia. Both quantitative and qualitative methods were used to collect data. Mathematics anxiety was assessed using the Mathematics Anxiety Rating Scale-Short Version (MARS-S) at the beginning and conclusion of a 12-week mathematics methods course. A short questionnaire assessing the participants' perceptions regarding the impact of the course and practicum on their level of comfort with mathematics was also administered. Analysis of data revealed that a large number of pre-service elementary teachers experience high levels of mathematics anxiety. Furthermore, participation in a mathematics methods course and practicum contributed to a statistically significant reduction in mathematics anxiety for pre-service teachers completing their first year of the teacher education program ($p \leq .05$). There was no significant change in the level of mathematics anxiety for the pre-service teachers in the second year of the program. Qualitative data indicated that the majority of pre-service teachers perceived the mathematics course and practicum as having a positive impact on their level of comfort with mathematics. The findings of this study have important implications for professors and administrators in teacher education.

Acknowledgements

I would like to express my sincerest gratitude to the following people who were instrumental in helping me to write this thesis:

To my husband and son, James and Peter Whiting, without their patience, encouragement, and support I would not have been able to complete this degree.

To my thesis advisor, Genevieve Boulet, whose guidance, enthusiasm, and dedication to mathematics education motivated me to complete this project.

To my committee member, Nezihe Elik, for her valuable feedback and suggestions that helped to shape my thesis.

To my mother, Maria Oszadszky, who without her generous support and encouragement completing another degree would not have been possible.

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Mathematics Anxiety in Pre-Service Elementary Teachers

Introduction

“Teachers cannot be expected to generate enthusiasm for a subject for which they have fear and anxiety. If the cycle of mathophobia is to be broken, it must be broken in the teacher education institution” (Mihalko, 1978, p. 36).

When asked to discuss their attitudes about mathematics, many adults may recount experiences learning mathematics in grade school, conjuring up feelings of anxiety, embarrassment, confusion, and disdain. Some people may recall negative memories, such as having to solve problems on the blackboard in front of their classmates, and others may express difficulty coping with everyday situations that require mathematical skills, such as calculating tips or determining their portion of a bill. Unfortunately, negative reactions to the subject of mathematics are not uncommon among the general population. Of particular interest to educators, therefore, is the finding that teachers play an important role in shaping attitudes about mathematics (Uusimaki & Nason, 2004).

As will be discussed, the National Council of Teachers of Mathematics (NCTM) emphasizes that teachers must work to promote positive attitudes about mathematics in their classrooms (NCTM, 1989). Teachers’ ability to do this, however, is compromised if they are experiencing anxiety toward mathematics. Research presented in this thesis suggests that teachers who experience mathematics anxiety may pass on this anxiety to the children they teach and this, in turn, may foster negative attitudes about the subject. In order to break this cycle, educators are encouraged to design teacher preparation programs that aim to alleviate the experience of mathematics anxiety among future teachers. It is the purpose of this study to examine levels of mathematics anxiety among pre-service elementary teachers registered in mathematics methods courses at a university in Nova Scotia. It is hoped that this research will provide insights into the impact of these courses on the level of mathematics anxiety experienced by the pre-service teachers. Ultimately, lessening the experience of

mathematics anxiety among teachers may help to foster positive attitudes towards mathematics among children.

In Nova Scotia, improving student success in mathematics is currently a priority for educators. In recent years, results of grade 12 mathematics provincial examinations have been poor and cause for significant concern. In 2007, only 64 percent of students passed this examination (Department of Education, 2008) and while the number of students who passed this exam rose to 71 percent in 2008, the Nova Scotia Education Minister, Karen Casey, noted that “there is no question that we still have much more work to do to better support students and teachers in this subject area” (Department of Education, 2008, p. 1).

Results from the 2006 Programme for International Student Assessment (PISA) underscore the need for Nova Scotia to focus on improving student performance in mathematics. A major aim of PISA is to assess the achievement of 15 year-old students in math literacy using a common international test (Statistics Canada, 2006). Fifty-seven countries participated in this study. Although Canada ranked highly in mathematics compared to the majority of other countries which participated in the study, students from Nova Scotia performed below the Canadian average, a finding that has been consistent with other PISA studies over the last several years (Statistics Canada, 2006).

In 2000, PISA conducted a study to examine factors related to mathematics performance (Statistics Canada, 2003). Consistent with other research, findings indicated that students with high levels of anxiety about mathematics performed lower on a mathematics test than students with less anxiety (Statistics Canada, 2003). Addressing mathematics anxiety is therefore one area that educators can focus on to help improve students’ performance in mathematics. Given the difficulties Nova Scotia students are encountering in this subject, attention to addressing mathematics anxiety in teacher training programs is certainly warranted.

This thesis includes five chapters. Chapter 1 begins by highlighting the issue of mathematics anxiety among pre-service elementary teachers. In light of this problem, the purpose of this study is discussed and the four research questions are presented. In Chapter 2, the general concept of mathematics anxiety is described, followed by a review of the literature pertaining to each of the research questions. A theoretical rationale providing justification for the study is also presented. A description of the methodology of the study is outlined in Chapter 3, including the research design, participants, instruments, and data collection and analysis procedures. The results of the research are presented in Chapter 4, including a discussion of the findings in relation to each of the research questions. Finally, the limitations of this research are acknowledged, and implications and directions for future research are presented in Chapter 5.

Chapter 1- The Problem

Few people would disagree that one of the most important qualities of a good teacher is the ability to generate enthusiasm about a subject. An enthusiastic teacher can engage students and foster a love of learning. But how can a teacher successfully convey enthusiasm about mathematics if she is anxious about mathematics? Unfortunately, as will be discussed, mathematics is a subject area that elicits anxiety in many elementary teachers. This finding is of significant concern because mathematics-anxious teaching may contribute to negative attitudes about mathematics among children (Hembree, 1990).

In this chapter, the problem of promoting positive mathematics-attitudes through addressing mathematics anxiety in pre-service teachers is described. Furthermore, the purpose of the study is outlined, including the primary goals and research questions. Finally, the significance of the study in light of the current shift in instructional practices towards teaching for understanding is discussed.

Statement of the Problem

Mathematics educators are well aware that attitude towards mathematics is a critical factor affecting students' learning of mathematics, their willingness to pursue advanced study of mathematics, and their career choice (Anku, 1996; Dutton & Dutton, 1991; Royster, Harris, & Schoeps, 1999). Mathematics anxiety is one factor that can impact students' attitudes towards mathematics (Sovchik, 1996 as cited in Vinson, 2001; Van de Walle, 1973) and the literature suggests that teachers play a critical role in fostering this anxiety (Uusimaki & Nason, 2004). Perhaps surprisingly, research has shown that pre-service elementary teachers have the highest levels of mathematics anxiety compared to other university students (Hembree, 1990). Findings from a recent study indicate that 66 percent of pre-service teachers reported that their mathematics anxiety began in

elementary school and the majority identified their teachers as the reason for their dislike and fear of mathematics (Uusimaki & Nason, 2004).

Many authors propose that mathematics-anxious teachers may pass on negative attitudes about mathematics to their students (Sovchik, 1996 as cited in Vinson, 2001; Wood, 1998). “Math-anxious teachers can result in math-anxious students” (Martinez, 1987, p. 117). Negative attitudes and mathematics anxiety can contribute to poor performance in mathematics and may impact a student’s future educational and career options (Gates, 2001; Post, 1992). As a result, it is important that teacher preparation programs address mathematics anxiety of future teachers in an effort to alleviate this “contagious anxiety” and promote positive attitudes toward mathematics in the children they teach (Vinson, 2001, p. 91).

Purpose of the Study

This study compares the levels of mathematics anxiety of pre-service elementary teachers at the beginning and conclusion of mathematics methods courses and practicum experiences. It further investigates pre-service teachers’ perceptions regarding what aspects of the courses and practicum experiences may have impacted their level of comfort with mathematics. It is the intention of this study to assess pre-service teachers’ general levels of mathematics anxiety and not specifically their anxiety toward teaching mathematics.

This research has two primary goals. The first is to examine changes in the levels of mathematics anxiety among first and second year pre-service elementary teachers participating in two mathematics methods courses, including practicum experiences. The second goal is to explore pre-service elementary teachers’ perceptions regarding how the mathematics methods course and practicum experiences impacted their level of comfort with mathematics.

Research Questions and Hypotheses

The proposed research aims to find answers to the following four questions:

1. How mathematics-anxious are pre-service elementary teachers in Nova Scotia?
2. Does participation in a mathematics methods course, including a practicum experience, have an effect on the level of mathematics anxiety in pre-service teachers?

H₀: There is no significant change in levels of mathematics anxiety among pre-service elementary teachers after participating in a mathematics methods course and practicum experience.

H_a: There is a significant decrease in levels of mathematics anxiety among pre-service elementary teachers after participating in a mathematics methods course and practicum experience.

3. Do second year pre-service teachers differ in the level of mathematics anxiety compared to first year pre-service teachers?

H₀: There is no significant difference between the levels of mathematics anxiety for first year and second year pre-service elementary teachers.

H_a: Second year pre-service elementary teachers experience less mathematics anxiety than first year pre-service elementary teachers.

4. What are pre-service elementary teachers' perceptions regarding how the mathematics methods course and/or practicum impacted their level of comfort with mathematics?

Significance of the Study

The outcome-based mathematics curriculum of Atlantic Canada is founded on the NCTM's Curriculum and Evaluation Standards for School Mathematics (Atlantic Provinces Education

Foundation, 1996; NCTM, 1989). The Foundation document for the Atlantic Canada Mathematics Curriculum acknowledges that teachers play a key role in creating a positive learning environment and highlights that the classrooms of today “must look very different from those of the past” (p. 31).

The Nova Scotia curriculum document summarizes important shifts to make in instructional practices, in an effort to foster positive attitudes toward mathematics and ultimately improve mathematics education. Most notably, teachers are encouraged to move away from instructing students to memorize procedures and to lead them toward mathematical thinking. Likewise, “teachers should move toward connecting mathematical ideas and applications rather than treating mathematics as a body of isolated concepts and procedures” (Atlantic Provinces Education Foundation, 1996, p. 31). The current curriculum in Atlantic Canada has been designed to facilitate students’ understanding of mathematical concepts. “The intent of this curriculum is to ensure that students understand these ideas, not just master the rules and procedures” (Atlantic Provinces Education Foundation, 1996, p. 28).

Furthermore, in keeping with the standards outlined by the NCTM, the Atlantic Provinces Education Foundation notes that teacher attitude toward mathematics is deemed to be an important aspect of the learning environment and key in fostering mathematically-minded students. The document states, “Teachers convey their attitude toward, and their value of, mathematics through their classroom presentation, responses to students’ ideas and solutions and in their assessment practices” (2008, p. 31). As previously stated, however, teachers experiencing mathematics anxiety may have difficulty demonstrating a positive attitude for mathematics in the classroom (Vinson, 2001).

In light of the current mathematics curriculum in Atlantic Canada, including the focus on understanding of mathematical concepts and the importance of fostering a positive attitude toward the subject, it is important to examine teachers’ attitudes toward mathematics, and in particular, their levels of mathematics anxiety. The intent of the proposed research is to investigate mathematics

anxiety in pre-service teachers because mathematics-anxious teachers may pass on their anxiety to the students they teach (see for example, Wood, 1988). Previous research suggests that how one is taught mathematics is a factor contributing to mathematics anxiety (Gresham, 2007). Since teachers tend to teach as they are taught, one possible solution to addressing mathematics anxiety in children “may lie in the preparation of teachers” (Gresham, 2007, p.183). Consequently, it is important to identify the extent to which mathematical methods courses in teacher training programs address mathematics anxiety in pre-service teachers. The findings from this research have important implications for how pre-service teachers are trained. Specifically, this research may be of benefit to those planning and delivering mathematics methods courses in Nova Scotia.

The research examining the effectiveness of mathematics methods courses in reducing mathematics anxiety is limited (Gresham, 2007) and, according to the researcher’s knowledge, to date no Canadian studies investigating this issue have been published. It should not be assumed that results of studies conducted in the United States are generalizable to Canada. While the Nova Scotia mathematics’ curriculum is based on the NCTM’s¹ Curriculum and Evaluation Standards for School Mathematics in the United States, Canada and the United States should not be considered to be synonymous with respect to mathematics performance. As previously noted, PISA reported that students in the United States performed well below the Canadian average in mathematics (Statistics Canada, 2008). This finding suggests that there may be differences in how students are taught in the United States and Canada.

¹ It is important to recognize that while the NCTM in the United States offers many valuable recommendations regarding mathematics education, the NCTM are not policy makers and therefore the recommendations of this body are not required to be implemented.

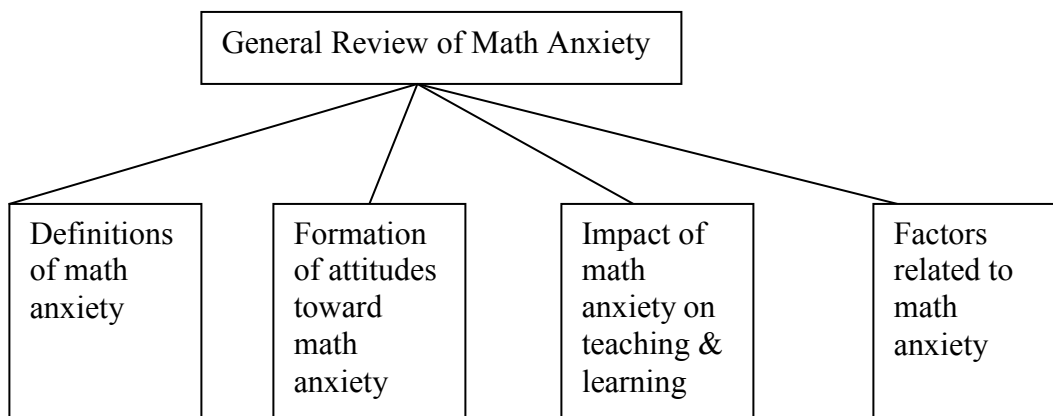
In summary, the overall purpose of this study is to examine the impact of mathematics methods courses and practicum experiences on levels of mathematics anxiety among pre-service elementary teachers. Research suggests that mathematics-anxious teachers may pass on their anxiety to the students they teach and as a result students may develop a poor attitude towards mathematics. A major goal of the Nova Scotia mathematics curriculum is to foster a positive attitude for mathematics among school-aged children. One possible strategy to achieve this goal is to alleviate mathematics anxiety among pre-service teachers through mathematics methods courses.

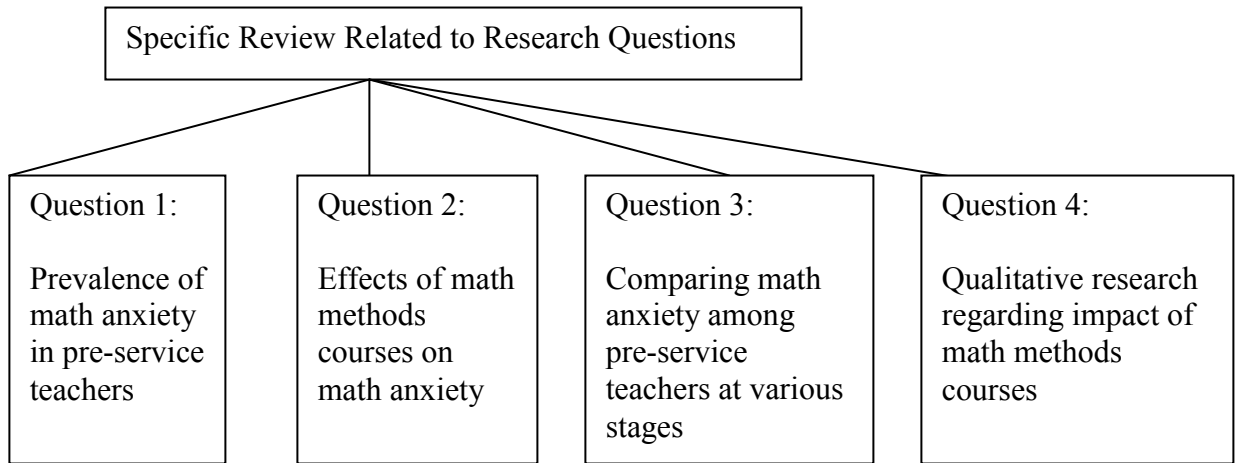
Following is a review of the mathematics anxiety literature as it relates to the purpose of this study. In addition, a theoretical rationale supporting the proposition that mathematics methods courses can be successful in decreasing mathematics anxiety is presented.

Chapter 2- Literature Review and Theoretical Framework

What is meant by the term mathematics anxiety? Many people say they first experienced anxiety about mathematics in elementary school (Uusimaki & Nason, 2004). Are teachers to blame? How does mathematics anxiety impact teachers and their students? It is important to have an understanding of the nature of mathematics anxiety and to attempt to answer such questions before addressing the specific issue of alleviating the experience of mathematics anxiety among pre-service teachers. Following a general review of mathematics anxiety, a more pointed review of the literature relative to each of the research questions is presented in this chapter. Figure 1 provides a schematic representation of the components of this literature review. Finally, educational and psychological theories are discussed to support the hypothesis that mathematics methods courses that focus on conceptual understanding can help lessen the experience of mathematics anxiety.

Figure 1: Overview of Literature Reviewed





General Review of Field

To facilitate an understanding of mathematics anxiety, the following section begins by reviewing how various researchers define this elusive concept. Research examining the teacher's role in the formation of attitudes towards mathematics as well as the impact of mathematics anxiety on teaching and learning will be highlighted. The intent of this section is to help the reader gain an appreciation as to the significant role teachers play in shaping attitudes towards mathematics as well as how mathematics anxiety can impair teaching, learning, and mathematics performance. Following this discussion, other factors that may contribute to the experience of mathematics anxiety, such as past experiences with mathematics and the extent of mathematics education obtained, will be briefly addressed to provide the reader with a more complete understanding of the nature of mathematics anxiety.

Definition of mathematics anxiety. The concept of mathematics anxiety has been defined in various ways in the literature. Although early research suggested that mathematics anxiety was a possible symptom of anxiety in general (Uusimaki & Nason, 2004), more recent research suggests that mathematics anxiety is a phenomenon much more complex than general feelings of anxiety (Hembree, 1990; Ingleton & O'Regan, 1998 as cited in Uusimaki & Nason, 2004). Broadly defined, anxiety is an

emotional state characterized by feelings of apprehension and fear (Lewis, 1970). Possible physical symptoms of anxiety may include nausea, profuse perspiration, headaches, and tight muscles, while mental symptoms may include confusion, disorganization, and memory problems (Arem, 2003). In the academic setting, two subconstructs related to the omnibus construct of anxiety have been identified: test anxiety and mathematics anxiety (Hembree, 1990).

In a review of the literature addressing mathematics anxiety and elementary teachers, Wood (1988) notes the lack of agreement among researchers about its definition and measurement. He proposes that mathematics anxiety may not be a distinct construct because it has been found to be highly related to test anxiety. Other researchers suggest, however, that although there are many similarities between test anxiety and mathematics anxiety, they are not synonymous (Dew, Galassi, & Galassi, 1983; Hembree, 1990). According to Hembree (1990), test anxiety and mathematics anxiety are separate constructs. He notes, “only 37 percent of one construct’s variance is predictable from the variance of the other” (Hembree, 1990, p. 45). He states that mathematics anxiety is comprised of a “general fear of contact with mathematics,” including, but not limited to, classes, homework, and tests (Hembree, 1990, p. 45).

Hunt (1985) describes mathematics anxiety as “the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem” (p. 32). While Hunt’s definition emphasizes the emotional aspects of mathematics anxiety, other researchers focus on the effect of mathematics anxiety on mathematical performance (Wood, 1988). For example, Richardson and Suinn (1972) defined mathematics anxiety as involving “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations” (p. 551). This definition is consistent with Arem’s (2003) description of the process of math anxiety. Arem suggests that

mathematics-anxious people may experience physical and mental symptoms of anxiety which results in poor performance in mathematics, avoidance of mathematics, and feelings of failure.

Both Richardson and Suinn's and Arem's definitions of mathematics anxiety are consistent with a classic psychological theory of arousal, the Yerkes-Dodson Law (Kosslyn & Rosenberg, 2001). This theory states that people perform best when they are at an intermediate level of arousal. If an individual is overaroused, as with people who are experiencing high levels of anxiety, then he or she will have difficulty focusing and sustaining attention which will result in decreased levels of performance (Kosslyn & Rosenberg, 2001).

Some definitions describe other possible symptoms and effects of mathematics anxiety. For instance, Bandalos, Yates, and Thorndike-Christ (1995) define mathematics anxiety as involving "debilitating test stress, low self-confidence, fear of failure, and negative attitudes towards mathematics learning" (as cited in Bessant, 1995, p. 327). Furthermore, research suggests that mathematics anxiety may be particularly apparent when an individual is under evaluation (Brush, 1981, as cited in Conrad & Tracy, 1992; Tooke & Lindstrom, 1998). Many pre-service teachers have expressed that they experience mathematics anxiety when having to teach mathematics to their students during practicum because they are being watched and evaluated (Levine, 1996). Uusimaki and Nason (2004) reported that over one-third of pre-service elementary teachers that participated in a study cited mathematics practicum situations as causing significant anxiety due to "insecure feelings of making mistakes or not being able to solve it correctly" (p. 373).

Wood (1988) argues that regardless of the lack of agreement in the literature about the definition of mathematics anxiety, the fact remains that many teachers report negative feelings towards mathematics. He stated, "There is good reason to believe, therefore, that in spite of the inadequacies of the definition and measurement of mathematics anxiety, teachers who are rated as mathematics-

anxious by the scales that are presently in use probably do harbor significant and potentially detrimental feelings towards mathematics, whatever label we apply to those feelings” (Wood, 1988, p. 11). Further, regardless of the precise definition, it is generally agreed that mathematics anxiety can potentially interfere with learning and performance in mathematics (Gresham, 2007).

Formation of attitudes towards mathematics. Teachers are considered to play a powerful role in the formation of students’ attitudes towards mathematics (Gresham, 2007). Researchers have identified negative mathematics experiences in primary and secondary school as being possible causes of mathematics anxiety in university students, including pre-service teachers (Brady & Bowd, 2005; Levine, 1996; Uusimaki & Nason, 2004). As previously mentioned, in a study exploring the origins of mathematics anxiety using a sample of pre-service teachers, 66 percent of the participants reported that their mathematics anxiety began in primary school, with the majority identifying their teachers as the reason for their dislike and fear of mathematics (Uusimaki & Nason, 2004). Some participants highlighted unsympathetic teachers as contributing to their mathematics anxiety. One student in this study revealed, “I used to make lots of mistakes and I was always frightened... I vividly remember, actually in Grade 1, getting into huge trouble because I couldn’t fit a puzzle together. I vividly remember that. Just absolutely getting caned by this teacher” (Uusimaki & Nason, 2004, p. 373). Jackson and Leffingwell (1999) cited the following behaviors by teachers that have contributed to mathematics anxiety in their students: gender bias, uncaring attitude, anger, unrealistic expectation, embarrassing students in front of peers, and poor instruction. Harper and Daane (1998) also linked the onset of mathematics anxiety with experiences relating to mathematics instruction in elementary and secondary school. They stated,

“These experiences have tended to lower confidence in one’s mathematical ability which has led to mathematics avoidance by the time the student was in secondary school. Thus the elementary mathematics classroom might be considered as a beginning point for creating mathematics anxiety”(1998, p. 29).

Teachers who are mathematics-anxious may facilitate the development of mathematics anxiety in their students through ineffective teaching and negative attitudes about mathematics (Brady & Bowd, 2005; Kelly & Tomhave, 1985). Brady and Bowd (2005) described the mathematics anxiety experienced by pre-service teachers as a “cyclical phenomenon” (p. 45). The authors reported that many of the pre-service teachers who participated in their study felt discouraged from pursuing further mathematics instruction because of negative experiences with mathematics in grade school. Many of the participants, therefore, felt that their mathematics education was not sufficient to prepare them to teach math confidently. As will be discussed shortly, this lack of confidence may be demonstrated in the classroom through poor teaching practices and negative perceptions about mathematics may be passed on from teachers to their students. Likewise, Mihalko (1978) noted that teacher-training programs should be charged with the task of breaking this cycle. As seen in the introduction of this proposal, Mihalko stated that teachers “cannot be expected to generate enthusiasm for a subject for which they have fear and anxiety. If the cycle of mathophobia is to be broken, it must be broken in the teacher education institution” (1978, p. 36, as cited in Wood, 1988).

Impact of mathematics anxiety on teaching and learning. Royster, Harris, and Schoeps (1999) highlighted that effective teaching of mathematics is more than simply teaching mathematics concepts and procedures, “it also includes helping students develop their dispositions towards mathematics” (p.

317). Disposition² can be described as students' attitudes or beliefs about mathematics (Royster et al., 1999), and may be reflective of students' confidence, interest for, and willingness to learn mathematics (Anku, 1996). Teachers' attitudes towards this subject can impact the learning and instruction of mathematics (Royster et al., 1999). As a result, the National Council of Teachers of Mathematics (NCTM) has emphasized the need for teachers to consider affective issues such as attitude towards mathematics (Royster et al., 1999). According to the NCTM's Professional Standards for Teaching Mathematics, teachers must "model a disposition to do mathematics and demonstrate the value of mathematics as a way of thinking (National Council of Teaching Mathematics, 1991, p. 109).

Pre-service teachers who experience mathematics anxiety may also have negative attitudes about mathematics (Vinson, 2001). Mathematics anxiety, therefore, may interfere with a teacher's ability to model a positive attitude toward mathematics in the classroom (via poor teaching practices and behaviors), thus impacting student learning. Vinson (2001) noted, "negative attitudes *toward* mathematics can produce negative results *in* mathematics" (p. 90; emphasis in original). As is discussed below, researchers have suggested that mathematics anxiety in teachers may impact a teacher's confidence to teach the subject, which, in turn, may result in ineffective instructional practices as well as uncaring and hostile behaviors towards students. In contrast, Van de Walle (1973) reported a positive effect on students' understanding of mathematics when their teachers demonstrated positive attitudes in the classroom.

Mathematics anxiety has been related to confidence in teaching mathematics. Brady and Bowd (2005) reported that mathematics anxiety correlated negatively with pre-service teachers' confidence to teach mathematics during practicum experiences ($r = -.46, p < .01$). Reflecting a common theme, one pre-service teacher commented, "When teaching math to my students during placement I had a high level

² For the purpose of this thesis, the terms disposition and attitude will be used interchangeably.

of anxiety because I was worried about teaching them wrong or confusing them even more than when they started” (Brady & Bowd, 2005, p. 42). Similarly, Gresham (2008) found an inverse relationship between mathematics anxiety and self-efficacy in teaching mathematics. In her study, pre-service elementary teachers with high levels of mathematics anxiety were more likely to express doubt about their abilities to be an effective teacher, compared to pre-service teachers with lower levels of mathematics anxiety.

Not surprisingly, mathematics anxiety appears to have implications for instructional practices. Mathematics-anxious teachers have been found to spend less time planning mathematics lessons and are more likely to use math instruction time for non-mathematics related activities than less mathematics-anxious teachers, which can impair student learning of mathematics (Swetman et al., 1993, as cited in Brady & Bowd, 2005). Other research has found that teachers with high levels of mathematics anxiety are more likely to use traditional teaching approaches (e.g. lecture format, rote memorization, teaching math skills more than conceptual understanding) (Hembree, 1990; Vinson, 2001). Moreover, as highlighted by Gresham (2008) such teachers “devote more time to seatwork, assign the same work to everyone, focus only on whole group instruction, and spend less time toward problem-solving techniques and strategies, playing games, small group instruction, and meeting the specific needs of the individual learner” (p. 172).

Mathematics anxiety can impact mathematics education on a number of levels (Brady & Bowd, 2005). Results of Hembree’s (1990) meta-analysis indicate that mathematics anxiety can impair students’ performance and may result in future avoidance of mathematics and mathematics-related courses. Likewise, Meece, Wigfield, and Eccles (1990) found that mathematics anxiety has contributed to lower scores on standardized tests and grades in mathematics courses. The authors also reported that

students who experienced mathematics anxiety were less likely to pursue advanced mathematics education at the secondary and post-secondary levels (Meece, Wigfield, & Eccles 1990).

The finding that mathematics anxiety can impair performance in mathematics may be explained by the processing efficiency theory proposed by Eysenck & Calvo (1992, as cited in Ashcraft, 2002). According to this theory, general anxiety impairs working memory because anxious individuals focus on worry thoughts rather than the task at hand. With respect to mathematics, thoughts may concern lack of confidence in mathematics and paying attention to such thoughts acts as a secondary task, taking focus away from the math problem, thus impairing performance.

Factors related to mathematics anxiety. Using a sample of 238 education students from a small Canadian University, Brady and Bowd (2005) explored the influence of a variety of factors on attitudes towards mathematics and confidence in teaching the subject. Correlational methods were used to determine the relationships between mathematics anxiety, as measured by the Mathematics Anxiety Rating Scale (MARS), and the extent of participants' formal mathematics education, attitudes towards mathematics, and past experiences in mathematics instruction.

Perhaps not surprisingly, data indicated that formal mathematics education correlated negatively with levels of mathematics anxiety ($r = -.28, p < .01$). That is, students who achieved higher levels of formal education in mathematics tended to be less mathematics-anxious than students with less formal mathematics education. Prior experiences with formal mathematics instruction were also found to be related to mathematics anxiety, namely pedagogical techniques (e.g. reliance on rote memorization, pressure related to testing) and the teacher's attitude toward students (e.g. degrading comments). Moreover, levels of mathematics anxiety were found to be positively correlated with mathematics being a participant's least liked subject in school ($r = .52, p < .01$) and a negative

relationship was found between level of mathematics anxiety and reported enjoyment of studying mathematics in elementary school ($r=-.36$, $p<.01$) and secondary school ($r=-.45$, $p<.01$).

Specific Review Relative to Each Research Question

Question 1: How mathematics-anxious are pre-service elementary teachers in Nova Scotia? As previously stated, pre-service elementary school teachers have consistently been found to experience higher levels of mathematics anxiety compared to other undergraduate university students (Bursal & Paznokas, 2006; Gresham, 2007; Hembree, 1990; Kelly & Tomhave, 1985), although, to the best of the researcher's knowledge, no studies of this nature have been conducted in Nova Scotia. In a meta-analysis investigating the nature of mathematics anxiety, Hembree (1990) explored levels of mathematics anxiety for students from a variety of disciplines. The highest levels of mathematics anxiety were found in students training to teach in elementary school. Consistent with this finding, Kelly and Tomhave (1985) reported that pre-service elementary teachers experience higher levels of mathematics anxiety than other university students. More recently, Bursal and Paznokas' (2006) study found that more than half of the 65 pre-service teachers who participated in their research experienced high levels of math anxiety.

Question 2: Does participation in a mathematics methods courses, including a practicum, have an effect on the level of mathematics anxiety in pre-service teachers? Given the high levels of mathematics anxiety experienced by many pre-service elementary teachers, interventions designed to reduce mathematics anxiety is warranted. Although limited, researchers have investigated the effects of mathematics methods courses on levels of mathematics anxiety of pre-service teachers. The research in this area has been promising. Many of these studies have reported that mathematical methods courses have been successful in reducing the levels of mathematics anxiety among pre-service teachers

(Gresham, 2007). A recurrent theme in the literature suggests that mathematics methods courses that focus on conceptual understanding of mathematical content are most effective in combating mathematics anxiety (Gresham, 2007; Vinson, 2001).

Tooke and Lindstrom (1998) examined the effectiveness of three mathematics courses in reducing the mathematics anxiety of pre-service elementary teachers. Three cases were investigated including mathematics for teachers courses taught in a traditional manner, a non-traditional manner, and a mathematics methods course. The traditional instructional approach included lecture, homework, and examinations. In contrast, the non-traditional approach utilized strategies recommended by the National Council of Teachers of Mathematics (1989) including using manipulatives, making mathematics relevant, and using a variety of teaching strategies (e.g. open-ended questions, group work). The mathematics methods course included the same mathematical content as the traditional and non-traditional mathematics for teachers' courses, but it also addressed pedagogical issues (i.e. The lectures emphasized how teachers should teach the material to children and how children learn the material.)

In Tooke & Lindstrom's (1998) study, the Mathematics Anxiety Rating Scale for Adults (MARS-A) was administered to 111 students at the beginning and conclusion of the courses. Data indicated that the levels of mathematics anxiety for students who participated in the mathematics methods course were significantly reduced after taking the course. Interestingly, results of the study indicated that neither of the sections of the mathematics for teachers' course resulted in a reduction in levels of mathematics anxiety of pre-service elementary teachers.

The authors suggested that these results may be explained by the difference in presentation of the course material. The mathematics methods course emphasizes how the concepts would appear to

children and how to teach the material, as opposed to simply presenting the material to the pre-service teachers for their own learning.

More recently, Vinson (2001) also conducted a repeated measures study to investigate changes in levels of mathematics anxiety among 87 pre-service teachers registered in mathematics methods classes. Mathematics anxiety was measured using the MARS (Richardson & Suinn, 1972) at the beginning and conclusion of four sections of a mathematics methods course offered in the fall, winter, spring, and summer. The mathematics methods course emphasized Bruner's (1961) framework of developing conceptual knowledge before procedural knowledge.³ In addition, manipulatives were utilized to assist in concrete learning of mathematics. Data indicated a statistically significant reduction in levels of mathematics anxiety ($p < .05$) for the winter, spring, and summer sections of the course. The fall section resulted in less of a difference in math anxiety levels than other sections of the course. One possible explanation for this finding, as noted by the author, is that since it was the professor's first time teaching the course, the professor may have demonstrated more stress and uncertainty during that section compared to the subsequent sections.

A larger-scale study investigating mathematics anxiety in pre-service teachers was recently conducted by Gresham (2007). The participants of the study were 246 pre-service teachers registered in a mathematics methods course that focused on methods for teaching elementary mathematics and emphasized Bruner's (1961) framework of conceptual knowledge. As in Vinson's (2001) study, the participants completed the MARS (Richardson & Suinn, 1972) at the start and conclusion of the course. Gresham's study differs from previous studies investigating the effects of mathematics methods courses on levels of mathematics anxiety because the pre-service teachers in her study also

³ Conceptual knowledge is related to understanding the meaning of mathematical concepts and the meaning behind mathematical procedures (Miller & Hudson, 2007). In contrast, procedural knowledge is the ability to follow a set of steps to solve a mathematical problem, such as calculating the area of a room (Miller & Hudson, 2007).

participated in practical teaching experience on a weekly basis concurrently with the mathematics methods course. In addition, data was collected from students registered in different sections of the course over a period of four years. Qualitative methods such as journaling of thoughts during the practicum and methods course, informal interviews, and informal observations of pre-service teachers were also utilized in this study. The author reported that there was a statistically significant ($p < .001$) reduction in levels of mathematics anxiety in the pre-service teachers who completed a mathematical methods course.

The research examining the impact of mathematics methods courses on mathematics anxiety experienced by students is very limited in Canada; the researcher found only one study related to this issue. Anku (1996) examined the impact of a 12-week mathematics course that emphasized concept development on students' disposition toward mathematics. Participants in this study included *prospective* student teachers (i.e. students preparing to enter a teacher education program) in a Canadian university. On the first and last day of class, participants responded in writing to the question, "What does mathematics mean to you?" The responses were examined to determine a change in participants' disposition towards mathematics after taking the mathematics course. Anku reported positive shifts in mathematics disposition and indicated that creating a non-threatening classroom atmosphere and helping students develop mathematical understanding through activities that are meaningful and relevant to real life experiences were aspects that helped to foster positive attitudes towards mathematics.

To the researcher's knowledge, no Canadian studies have investigated the impact of mathematics courses on the level of mathematics anxiety experienced by pre-service teachers. Therefore, the current study is the first Canadian study exploring this issue. It is particularly important to investigate mathematics anxiety among pre-service teachers in Nova Scotia, given the relatively

poor performance of high-school students on Provincial and International mathematics examinations (Statistics Canada, 2006; Department of Education, 2008). In addition, most of the research conducted in this area has used measures other than the MARS-S which will be used in this study. The MARS-S is highly correlated with one of the most common instruments used in this field, the 98-item MARS, however it has a much shorter administration time (Suinn & Winston, 2003). Using a different instrument may help to increase the number of instruments that researchers can flexibly choose from.

Question 3: Do second year pre-service teachers differ in the level of mathematics anxiety compared to first year pre-service teachers? Malinsky, Ross, Pannells, and McJunkin (2006) investigated mathematics anxiety using a sample of 481 university students. The authors hypothesized that pre-service teachers in their final semester would experience less mathematics anxiety compared to other education students. Mathematics anxiety was assessed using the Mathematics Anxiety Rating Scale- Revised (MARS-R; Plake & Parker, 1982), an instrument based upon the 98-item MARS scale. Independent sample t-tests were conducted to compare the mean scores between two groups of participants. The data indicated that there was no significant difference in mean scores of mathematics anxiety for these groups. One limitation of this study is that the authors did not report whether the senior students completed more mathematics methods courses than the other participants in their study.

Very little research has examined the differences in levels of mathematics anxiety for students in different stages of a teacher education program. The current study compared the levels of mathematics anxiety for first and second year pre-service elementary teachers. The second year pre-service teachers have completed at least one more mathematics methods course than the first year pre-service teachers, in addition to having more practical teaching experience. It is possible that the second year pre-service teachers in the study may experience less mathematics anxiety than the first year

students as a result of this additional exposure to mathematics instruction and experience in teaching mathematics.

Question 4: What are pre-service elementary teachers' perceptions regarding how the mathematics methods course and/or practicum impacted their level of comfort with mathematics?

Several studies have utilized mixed designs incorporating both quantitative and qualitative methods to investigate the effects of mathematics methods course on levels of mathematics anxiety among pre-service elementary teachers (Gresham, 2007; Tooke & Lindstrom, 1998; Vinson, 2001). The qualitative aspects of these studies offer valuable insight into what pre-service teachers perceive as helping to address their mathematics anxiety. Vinson (2001) conducted informal questionnaire-guided interviews with some of the participants in her study. The author reported very little information about these interviews. However, the main finding was that pre-service teachers reported that they felt their mathematics anxiety lessened as a result of participating in the mathematics methods class because “they were better able to understand mathematics concepts and procedures when they were presented on the pictorial or concrete levels” (Vinson, 2001, p. 93). In contrast, the data also indicated that some students experienced an increase in mathematics anxiety. Interviews revealed that one possible reason for this increase was that these students were intimidated by working with manipulatives because they had never been exposed to manipulatives before and therefore had difficulty understanding how to teach with them. In conclusion, Vinson noted that what the participants were able to understand, they were able to teach and “what they are able to teach effectively will reduce the anxiety levels of their future students” (2001, p. 93).

As noted previously, Gresham (2007) used qualitative methods such as journaling, interview, and classroom observations in her research. Findings indicated that the majority of pre-service teachers believed that their reduction in mathematics anxiety could be attributed to the use of concrete

manipulatives in the mathematics methods course. Consistent with Vinson's (2001) research, however, some participants indicated an increase in mathematics anxiety due to unfamiliarity with manipulatives. Nevertheless, participants most frequently commented, "they felt as though their mathematics anxiety could have been prevented in elementary school, if they had received instruction of mathematical concepts through the use of concrete manipulatives" (Gresham, 2007, p. 186). Some students commented "mathematics was less 'foreign' to them, noting that their perceptions of their abilities to understand concepts were now enhanced" (Gresham, 2007, p. 186). The results of this study are consistent with Vinson's (2001) research. Both authors highlighted that conceptual understanding and the use of concrete manipulatives should be emphasized in mathematics methods courses for teacher preparation.

Participants in Gresham's (2007) study also attributed their reduction in mathematics anxiety to the enthusiasm of the instructor teaching the course. "The professor's enthusiasm and excitement towards teaching mathematics content including the inviting atmosphere of the mathematics classroom as produced by the professor" was commonly reflected in the participants' comments regarding aspects of the course that helped to reduce their level of mathematics anxiety. This finding is consistent with the literature, as previously discussed, suggesting that teacher attitudes can influence mathematics anxiety in the students they teach (Harper & Daane, 1998; Shields, 2005). In a review of the literature, Shields (2005) stated, "In order to alleviate math anxiety teachers first and foremost need to portray a positive, enthusiastic, helpful attitude, which communicates a love and usefulness for mathematics" (p. 1).

Similar to these studies, the current research incorporated a qualitative aspect. Participants were asked to write about what components of the course and/or practicum they believe impacted their level of comfort with mathematics. This research differs from the studies reviewed above in that

participants were asked to respond anonymously in writing, in contrast to other methods that have used face-to-face interview formats that are more likely to be subject to both social desirability and interview bias. Participants that were interviewed in the reviewed studies were not anonymous and therefore they may have provided answers that they thought the interviewer wanted to hear. In contrast, participants who are asked to write about their perceptions with the assurance that their responses are anonymous and confidential may be more honest and less likely to respond in a socially desirable way. Indeed, research has shown that respondents are more likely to give socially desirable responses during interviews than using a questionnaire method (Bowling, 2005). Furthermore, Bowling (2005) notes that questionnaire methods also avoid interviewer bias (i.e. characteristics of the interviewer may impact the responses of participant).

Theoretical Rationale

As previously noted, mathematics methods courses that focus on the understanding of mathematics concepts appear to be effective in reducing levels of math anxiety of student teachers (Hembree, 1990; Grouwns, 1992; Widmer & Chavez, 1982). Perkins (1993) draws a distinction between merely knowing something and understanding something. He suggests that understanding goes beyond knowing because understanding refers to “being able to carry out a variety of ‘performances’ concerning the topic,” such as making predictions based on knowledge (p.4). Findings from qualitative research suggest that a focus on teaching for understanding, including the use of manipulatives, is perceived to be particularly helpful in lessening the experience of mathematics anxiety for many pre-service teachers (Vinson, 2001). Constructivist theories of education may help to explain this finding.

Copley (1992) describes the constructivist approach as follows:

“The constructivist model, one of facilitating learning, views teachers as facilitators whose main function is to help students become active participants in their learning and make meaningful connections between prior knowledge, new knowledge and the processes involved in learning. The role of students from this perspective is to construct their own understandings and capabilities in carrying out challenging tasks.” (p. 681)

In its most basic form, constructivist theories suggest that knowledge is actively constructed by individuals, rather than being passively transmitted to the learner from a teacher (Boudourides, 1998). According to Boudourides (1998), Ernst von Glasersfeld (1995) fundamentally influenced contemporary mathematics education with his constructivist theory (von Glasersfeld, 1995). von Glasersfeld’s work suggests that knowledge is actively constructed by the learner and constantly adapts based on the learner’s experiences (Boudourides, 1998). von Glasersfeld suggests that teaching for understanding is not simply verbally explaining concepts. He posits:

“Verbally explaining a problem does not lead to understanding, unless the concepts the listener has associated with the linguistic components of the explanation are compatible with those the explainer has in mind. Hence it is essential that the teacher have an adequate model of the conceptual network within which the student assimilates what he or she is being told. Without such a model as basis, teaching is likely to remain a hit-or-miss affair. From the constructivist perspective, ‘learning’ is the product of self-organization” (1989, p. 136 as cited in Boudourides, 1998).

Consistent with von Glasersfeld’s (1995) theory, Bruner (1961) suggests that learning is a continuous process in which learners construct ideas based upon their current or past knowledge. In his book, *The Process of Education*, Bruner (1961) theorizes about how people learn and about how to facilitate learning through instructional practices. He suggests instructional approaches to foster

understanding through using concrete materials, pictorial activities, and problem solving using a symbolic approach (Gresham, 2007). According to Tobias and Weissbrod (1980), these activities as well as simulations, discoveries, and challenges are considered to be examples of learning in action which can help to promote conceptual understanding and in turn may help to reduce mathematics anxiety.

Bandura's (1997) social cognitive theory is also helpful in conceptualizing the finding that math methods courses have a positive impact on math anxiety. Central to Bandura's theory is the concept of self-efficacy. Self-efficacy beliefs can be defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances." (Bandura, 1986, p. 391). Self-efficacy beliefs can influence an individual's thoughts and emotional reactions (Pajares, 2002). If a person holds the belief that she cannot do mathematics, then this belief may contribute to feelings of anxiety when she is faced with a mathematics-related situation. As education students gain understanding of mathematical concepts in methods courses as well as practice in teaching mathematics, they may develop self-efficacy and as a result their feelings of anxiety about mathematics may decrease.

Developing feelings of self-efficacy in mathematics is particularly important for pre-service elementary teachers because they are expected to teach for understanding. In order to do this, pre-service teachers should have a deep conceptual understanding of mathematics (Bleicher, 2006). Unfortunately, as will be presented later in this thesis, many pre-service elementary teachers have limited background in mathematics. In fact, the Nova Scotia Department of Education requires only half a credit of university level mathematics for elementary teacher certification. As a result, teacher education programs should provide teachers with the special training that is needed to develop a

conceptual understanding of mathematics in order to help develop feelings of self-efficacy (Bleicher, 2006).

Constructivist theories and Bandura's (1997) theory of self-efficacy, therefore, provide possible theoretical interpretations for previous research suggesting that mathematics methods courses can lessen the experience of mathematics anxiety among student-teachers. A primary aim of the proposed study is to examine the levels of mathematics anxiety among pre-service teachers before and after completion of a mathematics methods course and practicum. Based on the previous theoretical discussion, it is hypothesized that participants will experience less mathematics anxiety after completing the course and practicum than prior to the course and practicum.

This chapter provided a description of the concept of mathematics anxiety. Although its definition has not been agreed upon in the literature, it is apparent that many teachers report negative feelings about mathematics. A discussion of the role teachers play in shaping students' attitudes about mathematics was presented in order to establish the link between teachers' mathematics anxiety and the attitudes of their students. Research was described that suggests mathematics anxiety has an impact on students' performance in mathematics, the desire to pursue advanced mathematics education, as well as on teachers' instructional practices. In relation to the four research questions that guide the proposed study, a summary of the literature was presented. Empirical evidence suggests that pre-service elementary teachers experience high levels of mathematics anxiety. Fortunately, research suggests that mathematics methods courses that emphasize conceptual understanding have been particularly helpful in lessening this anxiety. This chapter discussed these findings in light of constructivist theories and Bandura's (1997) theory of self-efficacy.

The study will contribute to the very limited research examining pre-service elementary teachers' mathematics anxiety in Canada. Specifically, the study will provide teacher educators with a better understanding of the extent of mathematics anxiety among their pre-service teachers. Given the relatively poor mathematics performance of students in Nova Scotia compared to the majority of other Canadian provinces, it is important to conduct research that may serve to lessen the experience of mathematics anxiety. The following chapter aims to describe the methodology that were used to investigate the four research questions of this study.

Chapter 3- Methodology

The primary intent of this study is to compare levels of mathematics anxiety of pre-service elementary teachers at the beginning and conclusion of mathematics methods courses and practicum experiences. As outlined in the first chapter, this study aims to answer the following four questions: 1) How mathematics-anxious are pre-service elementary teachers in Nova Scotia, 2) Does participation in a mathematics methods course, including a practicum experience, have an effect on the level of mathematics anxiety in pre-service teachers, 3) Do second year pre-service teachers differ in the level of mathematics anxiety compared to first year pre-service teachers, and 4) What are pre-service elementary teachers' perceptions regarding how the mathematics methods course and/or practicum impacted their level of comfort with mathematics?

In this chapter the methodology of this study is described. The research design, participant characteristics, assessment instruments, and treatment conditions are outlined. A discussion of how participants were recruited and procedures used for collecting data in light of ethical considerations follows. In addition, data analysis procedures are outlined for each of the research questions.

Research Design

This study uses both quantitative and qualitative research methods. It incorporates a repeated measures design because the central purpose of the study is to compare the levels of mathematics anxiety at the beginning and conclusion of mathematics methods courses and practicum experiences in a sample of pre-service elementary teachers. The same sample of individuals were measured in the beginning stages of the mathematics methods course (pretest) and again in the final stages of the course (posttest), approximately three months after the initial measurement. The dependent variable in

the study is the level of mathematics anxiety, as measured by the Mathematics Anxiety Rating Scale-Short Version (Suinn & Winston, 2003).

In addition to the quantitative nature of the proposed research, the study also incorporates a qualitative component in order to gain insight into the particular effects of the mathematics methods course and practicum on the experience of mathematics anxiety. The qualitative data was obtained from an open-ended question addressing participants' perceptions of what aspects of the mathematics methods course and/or practicum impacted their level of comfort in mathematics.

Participants

The participants in this study consisted of 99 first and second year Bachelor of Education students registered in elementary mathematics methods courses at a university in Nova Scotia. Following is a description of the participant characteristics including gender, age, years of university education completed, year of study in Education program, highest level of mathematics instruction obtained, and number of university level mathematics courses completed.

Gender. Out of the total sample of 99 participants, 87 are female and 11 are male. Thus, approximately 89 percent are female and 11 percent are male. One participant did not complete this question.

Age. The frequencies and percentages for age are presented in Table 1 and descriptive statistics are presented in Table 2. The ages of the participants range from 21 to 52, with a mean age of 26.58 years and a standard deviation of 6.05. The majority of the subjects, approximately 85 percent, are between the ages of 21 and 30.

Table 1

Frequencies and Percentages for Age

Age	Frequencies	Percentages
21	4	4
22	14	14.6
23	21	21.9
24	14	14.6
25	6	6.3
26	3	3.1
27	4	4.2
28	3	3.1
29	7	7.3
30	6	6.3
31	2	2.1
32	1	1.0
33	1	1.0
34	1	1.0
35	2	2.1
36	1	1.0
40	1	1.0
41	1	1.0
45	1	1.0
46	1	1.0
47	1	1.0
52	1	1.0

Total	96	100
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Table 2

Descriptive Statistics for Age

Mean	26.68
Mode	23.00
Median	24.00
Standard Deviation	6.05

Years of University Education Completed. The frequencies and percentages for years of university education completed are presented in Table 3 and descriptive statistics are in Table 4. The number of years of university education completed ranges from 3 to 9 years, with the mean number of years being 5.07 and a standard deviation of 1.15. Almost 71 percent have completed between 4 and 5 years of university and approximately 21 percent have completed between 6 and 7 years of university.

Table 3

Frequencies and Percentages for Years of University Education Completed

Years	Frequencies	Percentages
3	3	3.0
4	29	29.3
5	42	42.4
6	13	13.1
7	8	8.1
8	3	3.0
9	1	1.0
<hr/>		
Total	99	100

Table 4

Descriptive Statistics for Years of University Education Completed

Mean	5.07
Mode	5.00
Median	5.00
Standard Deviation	1.15

Teacher Training. Participants were asked to identify if they were in the first or second year of studies in the Bachelor of Education program. As shown in Table 5, out of the total sample of 99 participants, 44 were first year students and 55 were second year students.

Table 5

Frequencies and Percentages for Year of Study in Education Program

Years	Frequencies	Percentages
1	44	44.4
2	55	55.6
<hr/>		
Total	99	100

Table 6

Descriptive Statistics for Year of Study in Education Program

Mean	1.56
Mode	2.00
Median	2.00
Standard Deviation	.50

Level of Mathematics Instruction Obtained and Number of Courses. Participants were asked to identify the highest level of mathematics instruction obtained as well as the number of university mathematics courses completed. As is shown in Table 7, almost 94 percent of the participants reported that the highest level of instruction completed was at the undergraduate level. Furthermore, as shown in Table 8, almost 64 percent of students previously completed between 1 and 2 university courses in mathematics and almost 32 percent previously completed between 3 and 4 university courses in mathematics. The mean number of university level mathematics courses completed was 2.26 with a standard deviation of 1.08.

Table 7

Frequencies and Percentages for Highest Level of Mathematics Instruction Obtained

Level	Frequencies	Percentages
High School	4	4.0
Undergraduate	93	93.9
Graduate	2	2.0
Total	99	100

Table 8

Frequencies and Percentages for Number of University Mathematics Courses Completed

Number	Frequencies	Percentages
0	1	1.1
1	22	23.4
2	38	40.4
3	22	23.4
4	8	8.5
5	2	2.1
6	1	1.1
Total	94	100

Table 9

Descriptive Statistics for Number of University Mathematics Courses Completed

Mean	2.26
Mode	2.0
Median	2.0
Standard Deviation	1.08

Data were also examined according to the participants' year of study in the Bachelor of Education program. As can be seen in Table 10, descriptive information for first (n=44) and second (n=55) year pre-service teachers was generally similar. As would be expected, however, the mean number of years of university education and university level mathematics courses completed was slightly higher for second year pre-service teachers, compared to first year pre-service teachers.

Table 10

Means for Pre-Service Teacher Demographic Variables According to Year of Study

Year	Age	Years of University Education Completed	Number of University Math Courses Completed
1	26.19	4.75	1.74
2	26.92	5.33	2.62

Instruments

During pre-testing, participants were asked to complete a brief self-report questionnaire including the Mathematics Anxiety Rating Scale-Short Version (MARS-S) and a demographic survey. During the post-testing phase of the study, participants completed the MARS-S for a second time in addition to providing written responses to one closed and one open question. A copy of the instruments are included in Appendix A. Following is a description of each instrument:

Mathematics Anxiety Rating Scale-Short Version (MARS-S). The Mathematics Anxiety Rating Scale-Short Version (Suinn & Winston, 2003) was used to measure levels of mathematics anxiety among pre-service elementary teachers at the beginning of a required mathematics methods course and again at the conclusion of the course. The scale was obtained directly from the test developer, Richard Suinn, and permission was obtained to use the scale for the purposes of this study (Appendix A).

The MARS-S is a 30 item self-rating scale that assesses mathematics anxiety (Suinn & Winston, 2003). The test items consist of behavioral situations that may elicit mathematics anxiety. Respondents are asked to rate their level of anxiety for each item using the dimensions of “not at all,” “a little,” “a fair amount,” “much,” or “very much.” Possible scores range from 30 to 150. The higher the score on the MARS-S, the higher the level of mathematics anxiety.

This short version of the MARS was developed from the original 98-item scale developed by Richardson and Suinn (1972). The original MARS is a reliable and valid instrument that has been widely used in mathematics anxiety treatment and research since 1972. However, to reduce administration time, Suinn and Winston (2003) developed a shorter version.

Using a sample of college students, Suinn and Winston (2003) conducted a study to create the shorter version and to provide reliability and validity information. Reliability and validity data for the MARS-Short Version is comparable to the original MARS (Suinn & Winston, 2003). The Chronbach alpha coefficient for the shortened version was calculated to be $r = .96$, demonstrating the internal consistency of the scale. The test-retest reliability over a one-week period was found to be $r = .90$ ($p < .001$). Convergent validity was assessed by correlating the scores of the MARS-S and the original MARS from the sample of college students. Suinn and Winston (2003) reported a strong positive correlation of $r = .92$ ($p < .001$). Similarly, when both tests were re-administered one week later, the correlation between the tests was found to be $r = .94$ ($p < .001$).

The MARS-S was selected for use in this study because it appears to be a reliable and valid instrument, with a short completion time, to assess the level of mathematics anxiety in university students. Suinn and Winston (2003) report that the MARS-S is equivalent to the original 98-item MARS.

Demographic questionnaire. Along with the MARS-S, a demographic questionnaire was administered to participants of this study at the beginning of the mathematics methods course. This questionnaire obtained information regarding participant characteristics including gender, age, years of university education completed, year of study in the Bachelor of Education program, highest level of mathematics instruction obtained, and number of university level courses in mathematics completed. The researcher developed all of the questions with the exception of the item that measures years of

university education completed. This question was taken from the Quality of Student Life Questionnaire which was developed by Clifton, Roberts, Welsh, Etchervery, Hasinoff, and Mandzuk (1992) and is available in the public domain.

This demographic information was sought because previous research has demonstrated that they are factors that may be related to the experience of mathematics anxiety (Brady & Bowd, 2005; Malinsky, Ross, Pannells, McJunkin, 2006). Although not the purpose of the current study, exploratory correlational analyses investigating the relationships between these factors and mathematics anxiety may point to interesting patterns that could have implications for future research. Finally, demographic information is useful in describing characteristics of the sample and allows the reader to assess the generalizability of the findings.

Follow-up questions. At the conclusion of the mathematics methods course, participants were asked to respond to the following two questions in addition to completing the MARS-S questionnaire.

1) Do you feel that the mathematics methods course that you completed this term and/or the practicum impacted your level of comfort with mathematics? (i.e. Do you feel that the course and/or practicum lessened or increased your level of comfort with mathematics?)

____ Yes, I feel that the course and/or practicum impacted (lessened or increased) my level of comfort with mathematics.

____ No, I do not feel that the course and/or practicum impacted my level of comfort with mathematics.

2) a) If you answered Yes to question #1, then respond to the following question:

What aspects of the course and/or practicum do you feel impacted your level of comfort with mathematics?

b) If you answered No to question #1, then respond to the following question:

Please explain why you think the course and/or practicum did not impact your level of comfort with mathematics.

The purpose of these questions was to investigate the participants' perceptions regarding the effects of the mathematics methods course and/or practicum experience on their level of comfort with mathematics. These questions are adaptations of interview questions used by Gresham (2007) in a recent study investigating mathematics anxiety in pre-service teachers.

Treatments

The treatment conditions in this study included two 12-week mathematics methods courses and practicum experiences. First-year students were registered in part one of a mathematics methods course, while second-year students were registered in part two of the course. Both courses were designed to help future teachers facilitate children's understanding of mathematical concepts. The primary goals of these courses are to help pre-service teachers develop an understanding of both mathematical concepts and how children learn mathematics. Consistent with constructivist theories of education, these courses aim to facilitate meaningful learning through the use of manipulatives and interactive activities. Although both courses shared common goals, the content differed. More specifically, part one of the mathematics methods course, completed by first year students, focused on numbers and operations. Conversely, part two of the course, completed by second year students, included the following topics: problem solving, probability, data management, geometry, measurement, as well as patterns and relations.

In addition to completing mathematics methods courses, students concurrently participated in a practicum experience in an elementary classroom that ranged over a period of two to five weeks (full-time). The practicum included both an observational period (i.e. where practicum students observed a classroom teacher) as well as direct teaching experience. It should be noted, however, that teaching of mathematics was only one component of the practicum.

Procedure

Sampling Technique. As previously stated, the participants in this study consisted of Bachelor of Education students registered in mathematics methods courses. The researcher made arrangements with professors to attend classes in order to recruit participants for the study. In an oral statement presented by the researcher at the time of recruitment, students were informed of the purpose of the study, the tasks required, as well as the anonymity and confidentiality of the data collected. The students were also informed that participation in the study was voluntary and would not influence their grade in the course (Appendix B). Students received a copy of this oral statement at the time of recruitment.

Recruitment occurred during the first week of classes in both the Fall and Winter terms of the 2008-2009 academic year. Volunteers were asked to remain in the classroom following the class in order to complete the questionnaire. The instructors left the class immediately after the lecture in order to ensure that they were not aware of who participated in the study.

Data Collection Methodology. Data was collected using a self-report questionnaire, as previously described in the instruments section. The data was collected at a university in Nova Scotia during both the initial and final stages of the mathematics methods courses. The researcher administered the questionnaires and was present during the research sessions. Each data collection session began with the researcher reading the informed consent form to the participants (Appendix C).

Each participant received a copy of this consent form. As with the recruitment statement, the consent form informed participants of the nature of the study, their right to withdraw from the study without penalty, as well as how the researcher would conserve anonymity and confidentiality of their responses.

Informed consent was obtained by using a written consent form that was not attached to the questionnaires (Appendix C). Participants indicated consent to participate through signing the form. Participants were also invited to include their name and email address on the consent form if they wanted a copy of the results of the study when it is completed.

Anonymity and confidentiality was maintained during data collection. The participants were not asked to include their names on the questionnaires. Instead, participants were asked to develop and include a pseudonym or code name on the questionnaires. Questionnaires and consent forms were stored in separate, but secure locations.

After all data was collected at the post-testing research session, the researcher orally explained the nature of the study and provided a written list of campus and community support services for the participants. (Appendix D). Participants also had the opportunity to ask questions following data collection and to obtain contact information for the researcher should participants have any further questions or concerns relating to the study.

A flow chart outlining the steps of this repeated measures design has been included in Appendix E.

Data Analysis. In addressing the first research question (How mathematics-anxious are pre-service elementary teachers in Nova Scotia?), the participants' raw scores, frequencies, and percentages relating to the levels of mathematics anxiety obtained, as measured by the MARS-S, are presented in the subsequent chapter. In addition, descriptive statistics including measures of central

tendency and standard deviation are presented in order to provide information regarding the average levels of mathematics anxiety among the sample of pre-service elementary teachers. Because this study is a repeated measures design, both pre- and post-test results are presented.

In addressing the second research question (Does participation in a mathematics methods course, including a practicum experience, have an effect on the level of mathematics anxiety in pre-service teachers?), paired t-tests (2-tailed) were calculated to determine if there was a significant difference between the pre- and post-test scores of mathematics anxiety for three groups, namely the first year students, second year students, and the total sample of first and second year students combined. The paired t-test is appropriate because this study incorporates a repeated measures design (i.e. a before and after study) that measures a single sample of individuals on two occasions (Gravetter & Wallnau, 2007).

In addressing the third research question (Do second year pre-service teachers differ in the level of mathematics anxiety compared to first year pre-service teachers?), the independent measures t-test (2-tailed) was calculated to compare the levels of mathematics anxiety for first and second year pre-service teachers, both at pre-test and post-test. The t-test for independent measures was used to address this question because data from two separate samples (i.e. first and second year pre-service teachers) was used to evaluate the mean difference in levels of mathematics anxiety between these two groups.

Qualitative methods were used to address the fourth research question (What are pre-service teachers' perceptions regarding how the mathematics methods course and/or practicum impacted their level of comfort with mathematics?). Prior to implementation of this study, a rubric was designed for interpreting responses and establishing themes (Appendix F). The possible themes included in the rubric were established based on previous research (Wood, 1988; Tooke & Lindstrom, 1998; Gresham, 2007).

This chapter outlined the research design, characteristics of the study's participants, instruments, as well as the procedure for conducting the study. Qualitative and quantitative methods were used in order to address the study's two primary goals: 1) to examine changes in levels of mathematics anxiety among pre-service elementary teachers participating in mathematics methods courses and practicum experiences and 2) to explore pre-service teachers' perceptions regarding how the course and/or practicum impacted their level of comfort with mathematics. In addressing the first goal of this study, quantitative methods were used. In particular, a repeated measures design was utilized because levels of mathematics anxiety among pre-service teachers in the beginning and final stages of a mathematics methods course and practicum experience were compared. In contrast, the second goal of the study was investigated using qualitative methods in order to gain a better understanding of what aspects of the courses and practicum may have contributed to changes in levels of mathematics anxiety.

Chapter 4- Results and Discussion

As has been discussed, research has pointed to the role teachers play in fostering mathematics anxiety in their students (see for example Uusimaki & Nason, 2004). Compared to other university students, pre-service elementary teachers have been cited as having the highest level of mathematics anxiety and it has been suggested that this anxiety and negative attitudes towards mathematics may be passed on to the students that they teach (Hembree, 1990; Sovchik, 1996 as cited in Vinson, 2001; Wood, 1998). This is a cause for concern, as anxiety about mathematics can impair students' performance in mathematics and can affect their willingness to pursue advanced study in mathematics, as well as their career choice (Anku, 1996; Dutton & Dutton, 1991; Statistics Canada, 2003).

As a result, some teacher preparation programs have attempted to address mathematics anxiety of future teachers through mathematics methods courses that are designed to focus on understanding of mathematical concepts. Limited research assessing the effectiveness of such courses has been conducted. The primary goals of this study, therefore, is to determine the effects of a mathematics methods course and practicum on the level of mathematics anxiety in pre-service elementary teachers and to explore the participants' perceptions regarding the impact of the course and practicum on their level of comfort with mathematics. To achieve these goals, both quantitative and qualitative methods were used. This chapter first presents the results of the study in relation to each of its four guiding questions, followed by a discussion of the findings.

Results

How mathematics-anxious are pre-service elementary teachers in Nova Scotia? The Mathematics Anxiety Rating Scale-Short Version (MARS-S) was used to assess levels of mathematics anxiety among pre-service elementary teachers. The frequencies and percentages for levels of mathematics anxiety experienced at the beginning (pretest) and conclusion (posttest) of a mathematics methods course and practicum are presented in Tables 11 and 12, respectively. Descriptive statistics are presented in Table 13. The participants' pretest scores ranged from 34 to 117, with possible scores for this scale ranging from 30 to 150. The participants' posttest scores ranged from 38 to 127. The mean pretest score is 69.85 with a standard deviation of 16.77, and the mean posttest score is 67.40 with a standard deviation of 17.49. Higher scores indicate greater levels of mathematics anxiety.

Individuals scoring above 78 are considered to be experiencing very high levels of mathematics anxiety and interventions, such as counselling, are recommended (Suinn, 2003). More specifically, a score of 78 indicates that a participant exhibits more anxiety than 75 percent of the normative group (i.e. undergraduate university students). As can be derived from Tables 11 and 12, 37 percent of pre-service elementary teachers that participated in this study experienced very high levels of mathematics anxiety (≥ 78) at pretest, decreasing to 27 percent after participation in a mathematics methods course and practicum (posttest).

Table 11

Frequencies and Percentages for Mathematics Anxiety: Pretest

Score	Frequencies	Percentages
34	1	1
35	1	1
40	1	1
42	1	1
44	1	1
46	3	3
47	1	1
48	3	3
49	1	1
50	1	1
51	3	3
53	2	2
54	3	3
55	3	3
56	1	1
58	3	3
59	2	2
60	1	1
61	2	2
63	2	2
64	3	3
65	1	1
66	2	2
67	2	2
68	2	2
69	1	1
70	1	1
71	1	1
73	2	2
74	4	4
75	1	1
76	1	1
77	5	5.1
78	4	4
79	2	2
80	3	3
81	5	5.1
82	1	1

Table 11 continued.

Frequencies and Percentages for Mathematics Anxiety: Pretest

Score	Frequencies	Percentage
83	2	2
84	3	3
85	4	4
86	1	1
88	2	2
91	4	4
94	1	1
97	2	2
104	1	1
113	1	1
117	1	1
Total	99	100

Table 12

Frequencies and Percentages for Mathematics Anxiety: Posttest

Score	Frequencies	Percentages
38	1	1.3
39	1	1.3
41	1	1.3
42	1	1.3
46	1	1.3
47	1	1.3
48	3	4.0
49	3	4.0
50	1	1.3
51	1	1.3
53	2	2.7
54	2	2.7
55	1	1.3
56	4	5.3
57	2	2.7
58	2	2.7
59	1	1.3
60	3	4.0
61	3	4.0
64	2	2.7
65	3	4.0
66	1	1.3
67	1	1.3
68	2	2.7
69	1	1.3
70	2	2.7
71	1	1.3
72	1	1.3
74	1	1.3
75	3	4.0
76	2	2.7
77	1	1.3
78	1	1.3
79	2	2.7
80	2	2.7
81	2	2.7

Table 12 continued.

Frequencies and Percentages for Mathematics Anxiety: Posttest

Score	Frequencies	Percentage
84	2	2.7
85	2	2.7
86	1	1.3
88	1	1.3
89	1	1.3
94	3	4.0
107	1	1.3
118	1	1.3
127	1	1.3
Total	75	100

Table 13

Descriptive Statistics for Mathematics Anxiety: Pre and Posttest

	Pretest	Posttest
Mean	69.85	67.40
Mode	77.00 *	56.00
Median	73.00	65.00
Standard Deviation	16.77	17.49

* Multiple modes exist. The smallest value is shown.

Does participation in a mathematics course, including a practicum experience, have an effect on the level of mathematics anxiety in pre-service teachers? The pretest and posttest mean scores for mathematics anxiety are presented in Table 14. This table reveals that the overall level of mathematics anxiety for the total sample of pre-service elementary teachers was reduced after participation in a mathematics methods course. The greatest reduction in mathematics anxiety occurred in the group of first year pre-service teachers (4.89). In contrast, the difference in the mean level of mathematics anxiety for second year pre-service teachers was negligible (.18).

Table 14

Mathematics Anxiety Raw Score Means

Year	Pretest	Posttest	n	Difference
1	71.25	66.36	36	4.89
2	68.54	68.36	39	.18
Total	69.84	67.40	75	2.4

To determine the significance of the differences between pretest and posttest means of mathematics anxiety, paired t-test comparisons were conducted for first year, second year, and the total group. As shown in Table 15, t-test comparisons revealed that the overall level of mathematics anxiety was found to be significantly reduced after participation in a mathematics methods course and practicum for first year pre-service teachers ($p < .05$), but the reduction in levels of mathematics anxiety for second year pre-service teachers and the total sample was not statistically significant ($p > .05$). Whenever a treatment effect is determined to be statistically significant, it is suggested that measures of effect size should also be reported (Gravetter & Wallnau, 2007). Cohen's d and the percentage of

variance were computed to determine the treatment effect size for the sample of first year pre-service teachers. The mathematics course was estimated to produce a medium effect ($d=.40$) on the level of mathematics anxiety. Furthermore, just over 14 percent of the variance in the difference score is explained by the effects of the mathematics methods course and practicum ($r^2 = .142$). Almost 86 percent of the variance, however, is not explained by the methods course and practicum and may be attributed to other variables and/or error in measurement.

Table 15

t-Test Comparisons of Pretest and Posttest Raw Score Means of Mathematics Anxiety Within Groups

Year	Variables	t	df	p
1	Pre-Posttest	2.41	35	.021*
2	Pre-Posttest	.086	38	.932
Total	Pre-Posttest	1.66	74	.102

* $p < .05$

Do second year pre-service teachers differ in the level of mathematics anxiety compared to first year pre-service teachers? The mean levels of mathematics anxiety for first and second year pre-service teachers were compared using the independent measures t-test (2 tailed). As shown in Table 16, prior to completion of a mathematics methods course (pretest), first year pre-service teachers experienced slightly more mathematics anxiety than second year pre-service teachers, but this difference was not found to be statistically significant ($p > .05$). After completion of the mathematics methods course (posttest), second year pre-service teachers experienced slightly more anxiety

compared to first year pre-service teachers. Again, the difference between the two groups was not found to be significant ($p > .05$).

Table 16

t-Test Comparisons of Pretest and Posttest Raw Score Means of Mathematics Anxiety Between Groups

	Pretest	Posttest
Year 1	70.91 (n=44)	66.36 (n=36)
Year 2	69.00 (n=55)	68.36 (n=39)
t	.561	-.492
df	97	73
p	.576	.624

What are pre-service elementary teachers' perceptions regarding how the mathematics methods course and/or practicum impacted their level of comfort with mathematics? At the conclusion of the mathematics methods courses, participants were asked to complete two questions (see Chapter 3) to elicit their perceptions regarding the impact of the course and practicum on their level of comfort with mathematics. The participants' responses are presented in Appendix G. Responses addressing the effects of the mathematics methods courses are distinguished from the responses addressing the effects of the practicum experiences, whenever possible.

As shown in Table 17, analysis of data revealed that 69 percent of the total sample of participants perceived that the mathematics course and/or practicum increased their level of comfort

with mathematics. More specifically, it appears that more first year pre-service teachers perceived an increase in comfort with mathematics (73%) compared to second year pre-service teachers (65%).

Table 17

Percent of Perceived Change in Comfort Level With Mathematics

Year	Increased	Decreased	No change
1 (n=37)	73	8	19
2 (n=40)	65	20	15
Total (n=77)	69	14	17

Several themes emerged from the participants' responses. First, participants reported the following aspects of the course to be helpful in facilitating their level of comfort with mathematics: a) focus on understanding of content/different methods of solving problems, b) qualities of instructor/teaching style, c) instruction in teaching strategies, and d) review of material. The majority of participants attributed their increase in comfort level with mathematics to the course focus on understanding of content and different methods of solving problems (n=18). Participants commented that the course helped them to understand mathematical concepts, rather than simply memorizing procedures. For example, one participant noted: "I feel the course helped me understand the basics of a lot of math concepts that was missing in my education of math in elementary school. Rather than solving problems, getting to the answer right away, I learned to find out why and how to solve the problems first." Many participants also attributed their increased comfort in mathematics to the explicit instruction of teaching strategies in the course (n=12). Participants indicated that learning alternative ways of teaching mathematics helped to alleviate mathematics anxiety and increased their confidence

in teaching mathematics. Several participants indicated that they have not had formal instruction in mathematics for a number of years and thus the review of mathematics concepts and practice of procedures in the course helped to increase their comfort with mathematics (n=8). Instructor qualities were also cited as aspects of the course that helped to increase participants' comfort with mathematics. One participant commented, The instructor's "lessons that explained the processes and background behind certain concepts and her guidance through the concepts gave me confidence and less anxiety."

Second, participants reported that the following aspects of the practicum increased their level of comfort with mathematics: a) observing a model, b) gaining practice in teaching mathematics, and c) developing lesson plans and materials for teaching mathematics. Five students reported that practice in teaching mathematics during the practicum helped to improve their comfort level with mathematics. For example, one student wrote, "Teaching math in my practicum actually increased my level of comfort with mathematics. I was the teacher so I had time to prepare and understand the concepts." Likewise, two other students specified that developing lesson plans and materials helped to improve their confidence in mathematics. Furthermore, two students indicated that watching their practicum supervisor teach mathematics lessons helped to reduce their anxiety.

As shown in Table 17, 14 percent of participants (n=11) perceived that the course and/or practicum decreased their level of comfort with mathematics. More specifically, second year pre-service teachers were more likely than first year pre-service teachers to report a negative impact. Pre-service teachers suggested that the "new way of teaching math" (i.e. focus on understanding and using manipulatives) was confusing to them. In addition, some participants revealed that the course highlighted their lack of knowledge thus decreasing their confidence in mathematics. Two participants noted that instructor characteristics, such as teaching at too quick a pace and lack of clarity and support, lessened their level of comfort with mathematics.

Finally, 17 percent of participants (n=13) did not feel that the mathematics methods course and/or practicum impacted their level of comfort with mathematics. Some students commented that they already felt comfortable with mathematics, while others indicated that they do not typically get stressed easily.

Discussion

Consistent with findings reported in the literature, the results of this study revealed that a large percentage of pre-service elementary teachers experience high levels of mathematics anxiety (see for example Bursal & Paznokas, 2006; Gresham, 2007, Hembree, 1990). As previously noted, scores above 78 on the MARS-S are considered to be reflective of very high levels of mathematics anxiety and interventions addressing this anxiety is recommended (Suinn, 2003). Prior to completion of a mathematics methods course and practicum, 37 percent of the participants received a score of 78 or above on the MARS-S. Although this proportion dropped to 27 percent at the conclusion of the course and practicum, the data indicates that a significant number of students preparing to teach in elementary schools are highly anxious about mathematics even after completion of a preparatory mathematics methods course and practicum. Moreover, according to normative data provided by Suinn (2003), scores of 78 or above fall at or above the 75th percentile, suggesting that an alarming number of pre-service elementary teachers experience levels of mathematics anxiety that is greater than a large proportion of other undergraduate university students.

The finding that many pre-service elementary teachers experience high levels of mathematics anxiety may be reflective of a lack of formal mathematics instruction. Previous research using a sample of pre-service elementary teachers in Canada revealed that students who achieved higher levels of formal education in mathematics tended to be less anxious about mathematics than students with

less formal education (Brady & Bowd, 2005). As previously outlined in Chapter 3 (Table 10), the mean number of undergraduate mathematics courses taken was only 1.74 and 2.62 for pre-service elementary teachers in the first and second year of the training program, respectively. In fact, the majority of first year students (87 percent) and almost half of second year students (49 percent) have not completed more than 2 undergraduate courses in mathematics prior to enrolling in the mathematics methods course.

It is also possible that pre-service elementary teachers may experience heightened mathematics anxiety because they are expected to teach mathematics and therefore must demonstrate competency in this area. Research suggests that mathematics anxiety increases when an individual perceives to be under evaluation (Wood, 1988). Although this study did not assess level of anxiety in teaching mathematics, it is possible that pre-service teachers' anxiety about mathematics was elevated due to the anticipation of having to teach mathematics in front of supervisors and respond to students' questions during the practicum.

The results of this study provided partial support for the hypothesis that completion of a mathematics methods course and practicum can decrease the level of mathematics anxiety experienced by pre-service elementary teachers. The findings indicated that while mathematics anxiety was lessened for both first and second year pre-service teachers after completion of the course and practicum, results were only statistically significant for first year pre-service teachers and very little change was observed in the second year group. These results are generally consistent with other research exploring the effects of mathematics methods courses. Although the literature has typically shown significant decreases in levels of mathematics anxiety among samples of pre-service teachers (see for example Gresham, 2007; Vinson, 2001), non-significant results have also been reported. For example, Vinson (2001) reported that while a significant decrease in mathematics anxiety was found

for three groups of students in her study, one group did not show a significant decrease. The author reasoned that the lack of significant results in that group may have been because it was the instructor's first time teaching the course. Therefore, the professor may have exhibited more uncertainty at that time compared to teaching subsequent groups.

In a similar vein, it is also possible that instructor-related factors may have accounted for the lack of significant results for the group of second year pre-service teachers in the current study. Three instructors taught the mathematics methods courses. While one of the instructors taught both courses, a second instructor co-taught the course for first year pre-service teachers, while a third instructor co-taught the course for second year pre-service teachers. Lending support to this theory, qualitative analysis of participants' responses to the follow-up questions revealed that second year pre-service teachers made several comments relating to the ineffectiveness of an instructor's teaching style and clarity of instruction, while first year pre-service teachers did not make any negative instructor-related comments.

It is also possible that the difference in results for first and second year pre-service teachers may be attributed to differences in course content for parts one and two of the mathematics methods course. As previously outlined, first year pre-service teachers completed part one of the course, focusing on numbers and operations. Second year pre-service teachers, however, completed part two of the course which covered several more complex topics such as problem solving, probability, data management, and geometry. Second year pre-service teachers, therefore, were not only expected to learn more material than first year pre-service teachers, but most of the material covered was also more complex than that taught in part one of the course.

It is important to note, therefore, that the current study is limited because the instructors and course content were not the same for first and second year pre-service teachers. These additional variables may have accounted for the differences in results between the two groups.

Other differences in methodology as well as differences in participant characteristics may explain the slight discrepancy between the findings of this study compared to similar research. For example, Gresham (2007) reported a significant decrease in mathematics anxiety in a sample of 246 pre-service elementary teachers. All participants in her study, however, had completed at least 3 university-level mathematics courses prior to completing the mathematics methods course. In contrast, the mean number of university-level mathematics courses completed by participants in the current study was just 2.26, with the majority (almost 64 %) completing only 1 or 2 courses. Therefore, the participants in Gresham's study have had more prior instruction in mathematics, a factor that has been found to be negatively correlated with mathematics anxiety (Brady & Bowd, 2005). Furthermore, there were a number of differences in the methodology of the studies. In addition to the mathematics methods course, the participants in Gresham's study completed a 12-week practicum and were required to keep a journal recording their thoughts and experiences throughout the course and practicum. In contrast, participants in the current study completed only 2 to 5 weeks of practicum and were not asked to maintain a journal. It is possible that the extensive practical teaching experience as well as journal writing contributed to the overall decrease in the level of mathematics anxiety in Gresham's study.

Qualitative analysis of participants' perceptions regarding the impact of the methods course and practicum on their level of comfort with mathematics is consistent with previous research and lends further evidence suggesting that these experiences can help to reduce mathematics anxiety. More specifically, analysis of participants' responses revealed that 73 percent of first year students perceived

an increase in comfort level. This finding lends support to quantitative data showing a statistically significant decrease in mathematics anxiety, as measured by MARS-S, for first year students after participation in the course and practicum. Although the change in level of mathematics anxiety was minimal for second year students, according to quantitative data, qualitative analysis of comments from second year students revealed that 65 percent perceived an increase in comfort level with mathematics following completion of the course and practicum.

Similar to findings reported in the literature, a large proportion of the total sample of participants attributed their increase in comfort with mathematics to the focus on understanding mathematical concepts in the methods course (Gresham, 2007). In addition, similar to previous research, participants cited gaining practice teaching and learning specific strategies for teaching mathematics as being important factors in increasing their level of comfort. These findings may help to explain why the level of mathematics anxiety decreased, as measured by the MARS-S, as well as why the majority of the participants perceived an increased level of comfort with mathematics after participation in a mathematics methods course and practicum.

As previously explained, the positive impact of teaching for understanding of math concepts and gaining practice in teaching mathematics may be interpreted by Bandura's concept of self-efficacy (1997). As students' gain an increased understanding of mathematical concepts they may feel more prepared to teach mathematics to others, thus developing feelings of self-efficacy which, in turn, may reduce mathematics anxiety. One student's comment highlights this idea, " I feel this course confronted my misconceptions about math and broke down the barriers of how I usually think so that I could truly understand what is taking place with math concepts. I feel it has given me an opportunity to think outside the box in math and has given me a stronger foundation for teaching it." Likewise, actual practice in teaching mathematics may also help students to feel more capable and less anxious. One

student commented, “After I taught math in my practicum I realized that if I take time to understand the language and concepts and teach student in different ways, with different tools, I’m not too overwhelmed.” This finding is also consistent with behavioral theories indicating that repeated exposure to anxiety provoking situations can help to reduce feelings of anxiety (Wolpe, 1997).

The current study also compared the levels of mathematics anxiety for first and second year pre-service teachers. Consistent with research conducted by Malinsky, Ross, Pannells, and McJunkin (2006), results indicated that there was not a significant difference in the mean scores of mathematics anxiety for these two groups, at both pretest and posttest. The results are seemingly inconsistent, however, with research suggesting that higher levels of mathematics education are negatively correlated with levels of mathematics anxiety, as previously described (Brady & Bowd, 2005). Furthermore, these results are not supportive of the proposed hypothesis that second year pre-service teachers would experience less mathematics anxiety compared to first year pre-service teachers as a result of additional exposure to mathematics instruction and experience in teaching mathematics. Intuitively, it would seem that additional knowledge and practical experience teaching mathematics would help pre-service teachers to feel more comfortable with mathematics. Although second year students have completed at least one more mathematics course and practicum than first year students in this study, the results suggest that this additional training is likely not significant enough to result in differences in levels of mathematics anxiety.

Alternatively, qualitative analysis of participants’ comments revealed that compared to first year students, more than twice as many second year students perceived a decrease in comfort in mathematics after completion of the course and practicum. Again, this finding is somewhat surprising in light of the extra course work and practicum experience for second year students. However, as previously discussed, it is possible that instructor-related factors may explain this difference.

The results of this study suggest that a relatively large number of pre-service elementary teachers attending a small university in Nova Scotia experience high levels of mathematics anxiety. While participation in a mathematics methods course and practicum contributed to alleviating mathematics anxiety to some extent among a group of pre-service teachers completing their first year of teacher training, significant effects were not observed for a group of students in the second year of the program. Lending support to the benefits of a mathematical methods course and practicum, however, it was the perception of the majority of students in this study (69 %) that the courses and practicum helped to increase their level of comfort with mathematics. A focus on understanding mathematical concepts, explicit instruction of teaching strategies, and gaining practical experience teaching emerged as common reasons for this perceived increase. As discussed in the next chapter, the results of this study have important implications for teacher training programs in Nova Scotia. Furthermore, limitations of this study and opportunities for future research will be discussed.

Chapter 5- Conclusion

This final chapter includes a brief summary of the study, followed by implications for university instructors and administrators, limitations, and directions for future research.

Summary

In Nova Scotia, improving mathematics achievement in school-aged children and youth is currently a priority for educators. Results of grade 12 provincial examinations in mathematics have been consistently poor in recent years and, on a national level, results of math literacy studies indicate that students from Nova Scotia have performed below the Canadian average for the last several years (Department of Education, 2008; Statistics Canada, 2006).

Mathematics anxiety is one factor that has been linked to poor performance in the subject and teachers are purported to play a critical role in fostering this anxiety (see for example Brady & Bowd, 2006; Gresham, 2008; Statistics Canada, 2003; Uusimaki & Nason, 2004). Alarming, research has shown that compared to other university students, pre-service elementary teachers have the highest levels of mathematics anxiety (Hembree, 1990). Moreover, many authors have proposed that math-anxious teachers may unintentionally pass on this anxiety to their students (Gresham, 2007). In fact, many pre-service teachers have identified their elementary school teachers as the reason for their fear and dislike of mathematics (Uusimaki & Nason, 2004). Hostile behavior, uncaring attitude, gender bias, embarrassing students in front of peers, and quality of instruction have been commonly cited as teacher characteristics resulting in negative attitudes and anxiety towards math (Furner & Duggy, 2002; Sheilds, 2005).

In an effort to break this cycle, teacher education programs have been encouraged to address mathematics anxiety in future teachers (Vinson, 2001). Mathematics methods courses that focus on the understanding of mathematical concepts on a concrete level have been shown to effectively alleviate mathematics anxiety in pre-service teachers (Gresham, 2007; Tooke & Lindstrom, 1998; Vinson, 2001). Research in this area is limited, however, and no Canadian studies investigating this issue have been published, to the researcher's knowledge. Therefore, it was the purpose of this study to explore the impact of a mathematics methods course and practicum on the level of mathematics anxiety among a sample of pre-service elementary teachers attending a small university in Nova Scotia. The following four questions were addressed: 1) How mathematics-anxious are pre-service elementary teachers in Nova Scotia, 2) Does participation in a mathematics methods course, including a practicum experience, effect the level of mathematics anxiety in pre-service teachers, 3) Do second year pre-service teachers differ in the level of mathematics anxiety compared to first year pre-service teachers, and 4) What are pre-service elementary teachers' perceptions regarding how the mathematics methods course and/or practicum impacted their level of comfort with mathematics?

Participants in the study included 99 first and second year students attending the Bachelor of Education program in a small university in Nova Scotia. Participants were volunteers registered in two mathematics methods courses, each of 12-week duration. In addition, participants concurrently completed a practicum that ranged between 2 and 5 weeks in length. A repeated measures design was used because the primary purpose of the study was to compare the levels of mathematics anxiety at the beginning and conclusion of the course and practicum. Quantitative and qualitative methods were incorporated into the design of the study.

At both pretest and posttest, mathematics anxiety was assessed using the Mathematics Anxiety Rating Scale- Short Version (MARS-S), a 30-item self-report questionnaire. A demographic

questionnaire was also administered at pretest to collect information regarding relevant participant characteristics (i.e. gender, age, years of university study completed, number of mathematics courses completed, year of study in Education program). At posttest, participants completed a brief questionnaire assessing their perceptions of the impact of the mathematics methods courses and practicum on their level of comfort with mathematics.

As expected, results indicated that a large number of pre-service elementary teachers who participated in the study experience high levels of mathematics anxiety. Paired t-test comparisons revealed that participation in a mathematics methods course and practicum contributed to a statistically significant decrease in mathematics anxiety for the group of pre-service teachers completing their first year of the Bachelor of Education program. Contrary to expectations, the overall decrease in mathematics anxiety among the group of pre-service teachers completing the second year of the program was not found to be significant. Mean levels of mathematics anxiety for the first and second year pre-service elementary teachers were also compared. The independent measures t-test revealed that there was no significant difference between the two groups, at both pretest and posttest. Analysis of qualitative data indicated that the majority of participants perceived the course and/or practicum as having a positive impact on their level of comfort with mathematics, providing further evidence supporting the effectiveness of mathematics methods courses in alleviating mathematics anxiety.

Implications

The findings of this study have important implications for how future elementary teachers in Nova Scotia are trained to teach mathematics. In particular, this research may be of benefit to university instructors and administrators in the development and implementation of mathematics methods courses. The finding that a large number of pre-service elementary teachers experience high

levels of mathematics anxiety, underscores the need to address this problem. As previously highlighted, teachers who are anxious about mathematics are unlikely to be able to teach the subject effectively and have the potential to pass their anxiety on to their students, which may, in turn, impair their learning of mathematics. Therefore, it is important for universities to be concerned with pre-service teachers' level of comfort with mathematics and with their confidence in their abilities to teach the subject.

A number of recommendations can be formulated from the results of this study. First, while participation in the mathematics methods course and practicum resulted in a statistically significant decrease in levels of mathematics anxiety, 27 percent of pre-service teachers continued to experience high levels (i.e. $\geq 75^{\text{th}}$ percentile). It would be advisable for university instructors of mathematics methods courses to monitor mathematics anxiety actively and refer pre-service teachers who demonstrate significant levels to counselling or other interventions (e.g. completion of a basic mathematics course, tutoring in areas of weakness, self-help books, etc.). Mathematics anxiety can be monitored through informal methods (such as interviews or review of journals) or formal measures such as standardized assessment tools (e.g. MARS-S).

Second, although the mean level of mathematics anxiety decreased slightly for second year pre-service teachers who completed the course and practicum, the results were not significant. Furthermore, compared to first year pre-service teachers, twice as many second year pre-service teachers reported that the course and/or practicum decreased their level of comfort with mathematics. These findings point to the importance of addressing mathematics anxiety in second year students and adjusting the content and delivery of the course in light of their comments. Comments from second year pre-service teachers revealed that instructor qualities such as teaching at too fast a pace and a lack of guidance to facilitate understanding contributed to a decrease in comfort with mathematics. The

mathematics methods course completed by second year pre-service teachers covered several more advanced topics than the course completed by first year students. It is recommended, therefore, that course developers consider adjusting the course content for the second year pre-service teachers to make it more manageable.

Interestingly, while many pre-service teachers identified a focus on understanding mathematical concepts as helping to increase their level of comfort with the subject, two second year students noted that this “new way” of teaching math was uncomfortable for them, suggesting extra assistance may be necessary for those students who have difficulty grasping this approach to mathematics instruction. Also, several second year students commented that the course highlighted their lack of knowledge in mathematics, indicating that that the course may have left them feeling unprepared.

Third, comments from the study’s participants offer valuable insights into aspects of the course and practicum that were beneficial in facilitating comfort with mathematics and thus should be considered by future instructors in the preparation and delivery of the courses. Most notably, with few exceptions pre-service teachers consistently identified that the focus on understanding mathematical concepts helped to facilitate their comfort with the subject area and, as one participant wrote, provided “a stronger foundation for teaching it.” Perhaps surprisingly, only one participant commented on the use of manipulatives in the course. Nevertheless, the comment was reflective of previous research highlighting that manipulatives are effective in helping students understand mathematics at a concrete level (Gresham, 2007). The overall lack of comments relating to manipulatives in the current study, however, suggests that manipulatives may not have been a core component of the course delivery. Given the value previous researchers have placed on the use of manipulatives in mathematics methods

courses, future instructors may be advised to emphasize more clearly their use in teaching mathematics.

Explicit instruction of teaching strategies for mathematics, instructor characteristics, and practical experience teaching were also cited by pre-service teachers as facilitating their comfort with mathematics. It was clear from their comments that pre-service teachers found learning various methods for teaching mathematical procedures and concepts to be very beneficial, both in helping to reduce their anxiety for teaching mathematics as well as in helping to improve their comfort with mathematics. In addition, the importance of instructor characteristics in helping to decrease mathematics anxiety cannot be overemphasized. In this study, many pre-service student teachers appreciated the guidance, patience, and support provided by instructors. However, as previously discussed, instructor-related factors may have also accounted for some participants' perceptions that the course decreased their level of comfort with mathematics. Previous research has highlighted the importance of instructor qualities in promoting comfort with mathematics. For instance, several researchers have cited the enthusiasm of the professor and their excitement towards teaching mathematics as being important factors (Anku, 1996; Gresham, 2007; Wood, 1988). Furthermore, as suspected, participants identified gaining practice teaching mathematics as helping to increase their comfort with mathematics, therefore highlighting the importance of including a practical component in the course and program.

Finally, data from this study indicated that four participants had never completed previous university level coursework in mathematics and several participants commented that it had been a long time since they had done mathematics. Although, the Bachelor of Education program at the university where the study was conducted requires completion of at least a half credit of fundamental mathematics at the undergraduate level, in accordance with competency levels set by the Nova Scotia

Department of Education for teacher certification, this requirement does not always need to be completed until the end of the degree program. Therefore, it is possible, as was seen in this study, that pre-service teachers are completing a mathematics methods course for teaching elementary mathematics with very little, if any, recent preparation in basic mathematics. Given the importance of mathematics as a core subject in elementary school classrooms and the findings of this study indicating limited formal education in mathematics among pre-service elementary teachers, government and university administrators should consider making requirements for mathematics instruction more stringent.

Limitations

The results of this study must be considered in light of several limitations. A key limitation relates to external validity or the extent to which the findings can be generalized to people and locations other than those used in the proposed research (Kazdin, 1992). Generalizability of the findings of the proposed study is limited because participants include only pre-service elementary teachers attending one university in Nova Scotia. Although it is the intention of this study to target elementary pre-service teachers, further research will be required to extend the findings to students in other teacher preparation programs across Canada.

The use of a self-report instrument to assess mathematics anxiety in the study is another limitation. Self-report measures are considered to be problematic due to potential bias (e.g. social desirability) as well as the absence of data showing that self-report measures are consistent with direct observation (Kazdin, 1992; Cone & Foster, 1993). At the same time, however, it is important to consider that internalizing problems (e.g. anxiety) are typically assessed by self-report measures because objective observation is problematic (Merrell, 2003). Nevertheless, to minimize the possibility

of bias in this study, participants were asked to complete the measures anonymously. In addition, an instrument with demonstrated reliability and validity was used to measure mathematics anxiety. It is acknowledged, however, that the generalizability of these findings is limited to self-reported perceptions of mathematics anxiety.

The lack of a control group is another important limitation of the proposed research that threatens the internal validity of the study. Without comparing the participants' data to a control group, it is impossible to know if factors other than the mathematics methods courses and practicum contributed to changes in levels of mathematics anxiety. The qualitative aspect of this study helps to explain the results, however, it is important to note that the data obtained for this part of the study is merely the self-reported perceptions of the participants regarding the impact of the mathematics methods courses and the practicum.

It is acknowledged that there are several potential compounding variables that were not controlled for and may have contributed to the results of this study. Events or experiences, outside of the mathematics methods courses and practicum, may have occurred between pre and posttesting that may have accounted for the change in mathematics anxiety (e.g. participants may have obtained therapeutic intervention for anxiety, participants may have completed tutoring in mathematics, etc.). In addition, as previously mentioned, although one instructor taught both the first and second year students, the co-instructors were not consistent across the two groups and therefore instructor-related variables were not constant for all participants. Likewise, the mathematics methods courses differed for first and second year pre-service teachers and therefore the content of the course was also inconsistent across groups, making between- group comparisons and analyses for the total sample of participants problematic. Demand characteristics may also have accounted for the study's outcomes. Demand characteristics are cues available that may provide information shaping the participants'

perceptions about the purpose of the research (Christensen, 1991). It is acknowledged that the researcher explained the general purpose of the study to the participants (see Appendix C: Consent Form) in order to obtain informed consent. As a result, however, participants may have identified the goals of the study and therefore their responses may have been biased in support of what they perceived the researcher's expectations to be.

Future Directions

This study contributes to the limited research investigating the effectiveness of mathematics methods courses in reducing mathematics anxiety in pre-service elementary teachers. To the researcher's knowledge this study is the only study of its nature conducted in Canada and therefore further research is needed to determine the generalizability of these findings to other Canadian teacher training programs.

Future research should also address methodological limitations of studies in this field. Most importantly, a review of the relevant literature revealed that none of the studies exploring the impact of mathematics methods courses on mathematics anxiety in pre-service teachers utilized a control group, according to the researcher's knowledge. As previously discussed, without a control group the internal validity of such studies is limited as extraneous variables may account for the study outcomes.

As previously discussed, findings from this study are consistent with previous research indicating mathematics methods courses can be effective in alleviating mathematics anxiety among pre-service teachers. The current findings were interpreted within Bandura's concept of self-efficacy (1997), suggesting that as pre-service teachers gain an improved understanding of mathematics concepts they are likely to become more confident in their mathematics abilities, which may serve to alleviate anxiety. Further research exploring a link between mathematics anxiety and self-efficacy in

teaching mathematics among pre-service teachers in Nova Scotia would therefore be a natural extension of this study. Moreover, while some research has identified an inverse relationship between mathematics anxiety and self-efficacy in teaching mathematics, there is limited research examining how mathematics anxiety and efficacy in teaching mathematics influences the teaching practices of pre-service elementary teachers and the subsequent performance of their students (Gresham, 2008). Such research may have important implications for teacher education programs and may further serve to highlight the importance of reducing mathematics anxiety in pre-service teachers in order to positively influence mathematics education in Nova Scotia's elementary schools.

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Appendix A: Questionnaire Components

Permission for Use of Math Anxiety Rating Scale-Short Version

From: [Richard Suinn](#)
To: ilona.oszadszky@msvu.ca
Cc:
Date: 07/17/08 10:06 pm
Subject: Re: MARS Brief
Attachments
:

That's a unique requirement. Of course you have my permission to administer the MARS. (What is more typical is a request for permission to reprint the test in the thesis/dissertation. In that circumstance, I provide permission to reprint no more than 10 items provided that the copyright declaration is also included.) BTW did you need a receipt?

On Jul 17, 2008, at 6:50 PM, Ilona Oszadszky wrote:

> Hello again Dr. Suinn:
>
> I am in the final stages of writing my thesis proposal, and I
> realized that I need your written permission to use the MARS-Short
> Version that I purchased from you recently. Could you please confirm
> with me that I have your permission to use this instrument in my
> study. My study will be examining levels of mathematics anxiety
> among a sample of student-teachers prior to and after completion of
> a mathematics methods course at Mount Saint Vincent University in
> Nova Scotia.
>
> Thank you. Ilona Oszadszky
>

Sample Items from the Mathematics Anxiety Rating Scale: Short Version

The items in the questionnaire refer to things that may cause fear or apprehension. For each item, place a check in the box under the column that describes how much you are frightened by it nowadays. Work quickly but be sure to consider each item individually.

	Not at all	A little	A fair amount	Much	Very Much
1. Taking an examination (final) in a math course.					
2. Thinking about an upcoming math test one week before.					
3. Thinking about an upcoming math test one day before.					
4. Thinking about an upcoming math one hour before.					
5. Thinking about an upcoming math test five minutes before.					
6. Waiting to get a math test returned in which you expected to do well.					
7. Receiving your final math grade in the mail.					
8. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.					
9. Being given a "pop quiz" in math class.					
10. Studying for a math test.					

These items are under copyright by Richard M. Suinn. All rights reserved. 2004

Demographic Questionnaire

Following are questions related to your personal background. Your answers to all questions are confidential and your identity cannot be traced from your responses.

This information will be used by the researcher to explore relationships between demographic characteristics and level of comfort with mathematics. Demographic information is also useful to describe the characteristics of the study participants as a group and allows the reader of the study to assess the generalizability of the research findings.

Please check one response for each question. You may skip questions that you do not wish to complete.

1. What is your gender?

Female Male

2. How old are you? _____ years

3. How many years of university education have you completed? _____ years
(If you have been a part-time student, then estimate the equivalent number of full-time years)

4. Indicate if you are in your first or second year of studies in the Bachelor of Education program. _____ 1st year _____ 2nd year

5. Indicate your highest level of **mathematics instruction** that you have completed to date.

Grade 12

Grade 13

Undergraduate university (List courses completed: _____

Graduate level university (List courses completed: _____

Follow-up Questions

Please respond to the following questions. The purpose of these questions is to gather information about your perceptions regarding the effects of the mathematical methods courses and practicum experiences on your level of comfort with mathematics.

1. Do you feel that the mathematics methods course that you completed this term and/or the practicum impacted your level of comfort with mathematics? (i.e. Do you feel that the course and/or practicum lessened or increased your level of comfort with mathematics?)

_____ Yes, I feel that the course and/or practicum impacted (lessened or increased) my level of comfort with mathematics.

_____ No, I do not feel that the course and/or practicum impacted my level of comfort with mathematics.

2. a) If you answered Yes to question #1, then respond to the following question:

What aspects of the course and/or practicum do you feel impacted your level of comfort with mathematics?

- b) If you answered No to question #1, then respond to the following question:

Please explain why you think the course and/or practicum did not impact your level of comfort with mathematics.

Appendix B: Oral Recruitment Statement

Recruitment Statement

I am a graduate student in the Faculty of Education at Mount Saint Vincent University. As part of my Master of School Psychology thesis, I am conducting research under the supervision of Dr. Genevieve Boulet, and I am inviting you to participate in my study, Mathematics Anxiety in Pre-service Elementary Teachers. The purpose of the study is to examine the levels of mathematics anxiety that student-teachers experience. It is hoped that the results of the study will help to lessen the experience of mathematics anxiety among student-teachers and ultimately to prevent mathematics anxiety among the students they teach.

This study involves completing a brief questionnaire at the end of this class today and again in approximately 12 weeks time. Completing the questionnaire today as well as during the follow-up session will take approximately 10 minutes each. The questions ask about your level of comfort when faced with a variety of mathematics-related situations. You will also be asked to answer some questions relating to your background. You may skip any questions that you do not wish to complete.

All responses will remain private and confidential. You will not be asked to include your name on the questionnaires. You will be asked to develop and include a pseudonym or code name on the questionnaires, but your identity cannot be traced from this information. All information collected will be stored in a secure location.

Participation in the study is voluntary and will not influence your grade in this course. You have the freedom to decline participation in the study at any point. My supervisor, Dr. Boulet, will not see the data collected until after you have received your grades in her class.

This research activity has met the ethical standards of the University Research Ethics Board at Mount Saint Vincent University.

If you would like to participate, then please remain in this room after the class and I will distribute the questionnaires at that time. Again, it will take approximately 10 minutes to complete the questionnaire today. Your professor will leave the class immediately after the lecture so he/she will not be aware of who participates in the study. Thank you.

Ilona Oszadzky, Graduate Student (School Psychology)

Appendix C: Consent Form

Consent Form

Title of Study:
Mathematics Anxiety in Pre-service Elementary Teachers

Name of Researcher:
Ilona Oszadszky

Supervisor:
Genevieve Boulet

I am a graduate student in the Faculty of Education at Mount Saint Vincent University. As part of my Master of School Psychology thesis, I am conducting research under the supervision of Dr. Genevieve Boulet, and I am inviting you to participate in my study, *Mathematics Anxiety in Pre-Service Elementary Teachers*. The purpose of the study is to examine the levels of mathematics anxiety that student-teachers experience. It is hoped that the results of the study will help to lessen the experience of mathematics anxiety among student-teachers and ultimately to prevent mathematics anxiety among the students they teach.

This study involves completing a brief questionnaire at the end of this class today and again in approximately 12 weeks time. Completing the questionnaire today as well as during the follow-up session will take approximately 10 minutes each. The questions ask about your level of comfort when faced with a variety of mathematics-related situations. You will also be asked to answer some questions relating to your background. You may skip any questions that you do not wish to complete.

Please do not put your name on the questionnaire. This way, your responses will remain anonymous and confidential. You are asked to develop and write a pseudonym (code name) on the questionnaire. Please use this same pseudonym on the questionnaire that you will complete in 12 weeks. Your professors will not be informed of your responses. All information collected will be stored in a secure location.

Participation in the study is voluntary and will not influence your grades in this course. You have the freedom to decline participation in the study at any point. My supervisor, Dr. Boulet, will not see the data collected until after you have received your grades in her class.

If you have any questions about this study, please contact Ilona Oszadszky at _____ or at ilona.oszadszky@msvu.ca. This research activity has met the ethical standards of the University Research Ethics Board at Mount Saint Vincent University. If you have any questions or concerns about this study and wish to speak with someone who is not directly involved with this study, you may contact the University Research Ethics Board, by phone at 902-457-6350 or by e-mail at research@msvu.ca.

By signing this consent form, you are indicating that you fully understand the above information and agree to participate in the study.

Participant's signature

Date

Researcher's signature

Date

If you would like a copy of a summary of the results of this study when completed, please write your name and address or email address below. If you do provide this information, it will be placed in a secure location separate from the questionnaires.

Name:

Address:

E-mail:

Appendix D: Resource List

Suggested Resources

If you would like help coping with your comfort with mathematics, then you may consider the following resources:

Personal Counselling:

Counselling & Psychological Services
Mount Saint Vincent University
Evaristus 218
Phone: 457-6567
Email: counselling@msvu.ca

Self-Help Guide:

Conquering Math Anxiety

Author: Cynthia Arem

This book is available for lending through the NovaNet Library system or for purchase through Chapters.

(Arem, C.A. (2003). *Conquering math anxiety* (2nd ed.). Pacific Grove, CA: Thompson Brooks/Cole.)

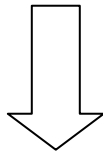
Appendix E: Steps of Procedure for Repeated Measures Research Design

Appendix E:

Steps of Procedure for Repeated Measures Research Design

1. Recruitment of Participants

- Participants include first and second year Bachelor of Education students in the elementary stream.
- First year students were recruited from a mathematics methods course in the Fall and Winter terms. Second year students were recruited from a mathematics methods course in the Fall term.
- The researcher presented an oral recruitment statement during the first week of classes



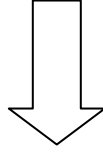
2. Collect Pre-test Data

Fall term:

- Self-report measures (i.e. MARS-S & Demographic questionnaire) were administered to first and second year student participants registered in the mathematics methods courses. The data collection sessions were held between September 15 and October 8.

Winter term:

- In the Winter term, a second group of first year pre-service teachers completed a mathematics methods course. Self-report measures, as above, were administered to participants registered in this class.
- The data collection session was held during the first week of January.



3. Collect Post-test Data

Fall term:

- Self-report measures (i.e. MARS-S & Qualitative Questions) were administered to the same sample of first and second year participants registered in the mathematics methods courses.
- The data collection took place during the last week of November.

Winter term:

- The same sample of first year pre-service teachers registered in the Winter section of a mathematics methods course were administered self-report measures (i.e. MARS-S & Qualitative Questions).
- The data were collected during the last week of March.

Appendix F: Response Rubric for Follow-Up Question 2

Pre-Service Teachers' Perceptions of Impact of Practicum Experience on Level of Comfort With Mathematics

	Teaching using manipulatives	Supervisor qualities	Classroom environment	Gaining practice teaching math	Developing lesson plans/materials for teaching	Confidence in teaching mathematics	Knowledge/skill in teaching strategies
Comfort Lessened							
Comfort Increased							
No Impact							

Appendix G

Pre-Service Teachers' Perceptions of Impact of Mathematics Methods Course and Practicum

Student Perceptions of Impact of Mathematics Methods Course:

Increased Comfort with Mathematics

Use of manipulatives

Working with manipulatives (hands on activities). This gave me better understanding of how to present material to students so that they understand it.

Focus on understanding of content/different ways of solving problems

The variation and ways of figuring out math problems and the way of thinking.

It made me realize that there are many different methods for solving problems than the ones that I am used to. It also made me realize why we use the mathematical concepts that we use to solve problems.

The way in which the course was taught really increased my comfort level with math as it was focused on math literacy rather than just the memorization of concepts. I found this easier to comprehend.

The topics covered were quite basic (addition, fractions, etc.) but they were explained in such detail that I have a better understanding of them.

Being shown different ways to solve math problems helped my anxiety.

Student Perceptions of Impact of Mathematics Methods Course: Increased Comfort with Mathematics Continued.

Focus on understanding of content/different ways of solving problems cont.

Conceptual approach enhanced understanding making me more comfortable in my own understanding thus more comfortable teaching students.

Instructor qualities/style

They helped me to back to the basic[s], take my time and have patience.

The instructor's lessons that explained the processes and background behind certain concepts and *her guidance* through the concepts gave me confidence and less anxiety.

The instructor's classes were wonderfully relevant and informative. Very helpful!

Emphasis on taking the time to get things right.

The course load was not rushed through so I wasn't overwhelmed.

Student Perceptions of Impact of Mathematics Methods Course: Increased Comfort with Mathematics Continued.

Instruction in teaching strategies

In certain areas I have learned different methods that may be easier for a child to understand.

Emphasis on multiple strategies for arriving at a correct response.

Learning how children think of math differently from adults and learning about how to make math more simple and concrete instead of it being so abstract.

Many useful suggestions were given for how to introduce and teach these topics in a classroom that I feel more confident in my ability to do so.

The part where we learned the different ways to solve and teach the same problem increased confidence and comfort level in doing math.

I learned the importance of organizing things for students to help them learn confusing concepts.

Having different approaches/strategies alleviates my math anxiety.

Student Perceptions of Impact of Mathematics Methods Course: Increased Comfort with Mathematics Continued.

Instruction in teaching strategies cont.

Learning more strategies to help teach math to elementary students. I feel that the course increased my confidence in math and helped me understand that there are many ways to come up with a possible answer to a question. I remember being taught one way to solve division problems. Things have changed.

Learning how to teach a few different areas of math in different ways helped.

The various ways that will help students cope (strategies).

Becoming refamiliarized with well-known concepts and ways of teaching them.

Having to do it the way I would teach helped me become more comfortable with teaching it.

Having more than one method for teaching helped me too.

Other

Just being familiarized with mathematics after being away from a math course for a while made me more comfortable.

Student Perceptions of Impact of Mathematics Methods Course: Increased Comfort with Mathematics Continued.

Other cont.

Just being able to review elementary mathematics again has increased my comfort level. Before I was nervous because it had been so long since I had done any math in a classroom.

Having some of the strategies and applications reviewed because I feel it's been a long time since I've done it.

Some aspects related to outcomes were beneficial.

Being re-taught the basics helps me remember the larger picture or more in-depth problems.

Practical math also helps it "sink in."

The ability to practice problems that build on theory we need to know is great practice for the real application in the class.

Being comfortable when the newer methods of teaching math that came from practicing them in the classroom.

Student Perceptions of Impact of Mathematics Methods Course: Increased Comfort with Mathematics Continued.

Other cont.

It helped because it reminded me of concepts that I had forgotten.

Understanding how a student who is unfamiliar with a concept goes through the learning process.

By going over the elementary math concepts, in both course and practicum, my confidence in teaching these concepts have been strengthened.

Practice, discussions, handouts.

Student Perceptions of Impact of Mathematics Methods Course:

Decreased Comfort with Mathematics

Focus on Understanding

I felt that concepts I felt I understood I am now confused about, especially in problem solving.

Instructor qualities/style

The instructor's lessons that just gave hard concepts and expect me to figure it out without a clear understanding increased my anxiety.

We go through the material really fast in class.

Instruction in teaching strategies

I feel more nervous about teaching certain topics that I am uncomfortable with (new ways of teaching math).

The new way that math is taught is unfamiliar to me and, thus, decreases my level of comfort.

Uncomfortable using correct mathematical language and terms.

Student Perceptions of Impact of Mathematics Methods Course:

Decreased Comfort with Mathematics Continued.

Instruction in teaching strategies cont.

I did not find it specific enough to teaching strategies, therefore lessened my level of comfort.

Other

I feel that while I am glad I took the course, I feel more anxiety in teaching math because I realize how much I don't know.

Makes me realize how much I don't know.

I feel like almost everything I was comfortable with, I am now uncomfortable with.

More anxious because realize that there are more things in math than I thought that I need to be comfortable with.

Student Perceptions of Impact of Mathematics Methods Course:

No Impact

I just don't tend to feel stressed.

Not overly new. Stuff I did before in other classes.

I feel I was fairly comfortable already and I'm not one who stresses easily.

Student Perceptions of Impact of Practicum:

Increased Comfort with Mathematics

Observing a model

Seeing a teacher doing it in a practicum helped.

Being able to witness what actually occurs in an elementary classroom.

Gaining practice in teaching mathematics

Practicum helped with seeing how things are completed in a hands- on approach. Watching students in action was a great learning experience.

Practicum gave me practice of teaching math.

Practicum made me see that what we learn in class is more difficult than what we actually have to teach.

Actually being able to teach successful math lessons in practicum affected my level of comfort.

Student Perceptions of Impact of Practicum:

Increased Comfort with Mathematics Continued.

Gaining practice in teaching mathematics cont.

After I taught math in my practicum I realized that if I take time to understand the language and concepts AND teach student in different ways, with different tools, I'm not too overwhelmed.

Developing lesson plans and materials for teaching mathematics

Teaching math in my practicum actually increased my level of comfort (with mathematics). I was the teacher so I had time to prepare and understand the concepts.

Being able to know that I am comfortable teaching math if I have prepared the night before.

