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Investigating and Overcoming Mathematics Anxiety in In-service Elementary School Teachers

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By

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ABSTRACT

Mathematics anxiety impedes learning and success in mathematics and could be a hindrance for both teachers and students. This sequential mixed methods research project examined the nature of mathematics anxiety among elementary in-service teachers and how the anxiety differs in terms of various demographic factors. It also investigated mathematics teaching anxiety, its types, and relationship with mathematics anxiety. Data were collected through an online survey completed by 111 elementary in-service teachers and follow up face-to-face interviews with four of them. Findings from the survey indicated that: 17.1% of them had low level of mathematics anxiety, 64% experienced a moderate level, and 18.9% had a high level of mathematics anxiety; female participants experienced higher mathematics anxiety than males; and there were no significant differences in the mathematics anxiety for White and non-White participants, by participants' mothers' educational level, and socioeconomic status. Other findings showed that: there was positive correlation between mathematics anxiety and mathematics teaching anxiety; female participants had higher mathematics teaching anxiety due to subject knowledge and self-confidence than males; and beginning teachers had higher mathematics teaching anxiety than experienced teachers. In the interviews, participants attributed the causes of mathematics anxiety to their teachers' teaching strategies, insensitive comments, and mean behaviors, and to their own lack of understanding of mathematics concepts. Lack of confidence in doing mathematics, lack of courage to express their feelings about mathematics to their teachers, negative attitude towards mathematics, and avoidance of mathematics courses were reported as aftermath effects of mathematics anxiety when participants were in school. Recommendations are made for joint efforts by the school boards, teacher educators, researchers, and parents to reduce mathematics anxiety among the teachers and break its re-occurring cycle and consequences.

DEDICATION

My dissertation is dedicated to my loving husband, son, two daughters, extended family, mentors, supportive friends, and colleagues.

Your words of encouragement and prayers made me persistent in the four years of academic journey that was a life-changing experience for me.

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INTRODUCTION

> *"Tell me mathematics and I forget, show me mathematics and I may remember; involve me… and I will understand mathematics. If I understand mathematics, I will be less likely to have math anxiety and if I become a teacher of mathematics, I can thus begin a cycle that will produce less math anxious students for generations to come" (Williams, 1988, cited by Stuart, 2000, p. 335).*

Since the early 1970s, mathematics anxiety has been an area of research and concern in North American society (Gresham, 2009; Hembree, 1990; Liu, 2008) as it affects both teachers and students. Mathematics anxiety is referred to as "feelings of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 544). It is also described as a person's negative affective reactions to situations that involve mathematics, numbers, and calculations (Ashcraft & Moore, 2009). These reactions range from mild to severe and could manifest through feelings of panic, discomfort, flurry, avoidance, fear of failure, a blank mind, and helplessness (Arem, 2003; Bekdemir, 2010; Woodard, 2004). Mathematics anxiety could weaken an individual's state of mind and eventually progress to mathematics avoidance and mathematics phobia (Tobias, 1978), resulting in low achievement in mathematics (Ashcraft, 2002; Ashcraft & Kirk, 2001). There is a negative relationship between students' mathematics anxiety and mathematics achievement (Hembree, 1990; Khatoon & Mahmood, 2010; Ma, 1999; Merritt, 2011; Standing, 2006; Woodard, 2004). According to Ashcraft and Moore (2009), "math anxiety is a significant impediment to math achievement, one that affects a considerable portion of the population and one that merits serious attention both in terms of assessment and intervention" (p. 197). Thus, mathematics anxiety impedes learning and success in mathematics and appears as a hindrance that causes students to fall short in realising their full potentials in schools. Given that mathematics anxiety interferes with learning and teaching in school settings, it is crucial to address the root causes of this phenomenon, its effects and the intervention strategies aimed at eliminating it. Specifically, tackling the issue of mathematics anxiety that some in-service elementary school teachers experience may prevent its transfer to their students and could lead to "maximum benefit in ameliorating math anxiety throughout the educational system" (Dunkle, 2010, p. 8).

Background and Rationale

Students with high levels of mathematics anxiety have negative attitudes toward mathematics, lack motivation to engage in it, and see mathematics as less useful than other academic areas (Ashcraft & Ridley, 2005; Jameson, 2010). Mathematics anxiety has negative effects on the students' mathematics performance and self-confidence, and it could begin as early as Grades 3 and 4 (Jackson & Leffingwell, 1999). Ma and Cartwright (2003) argue that, although all students experience some level of anxiety towards mathematics, the level of anxiety in females appears to be greater than in males. Early avoidance of mathematics may limit opportunities for females to pursue some lucrative careers in mathematics and sciences later in life (Altermatt & Kim, 2004). In a similar manner, "when otherwise capable students avoid the study of mathematics, their options regarding careers are reduced, eroding the country's resource base in science and technology" (Hembree, 1990, p. 34).

Researchers (Fiore, 1999; Geist, 2010; Sheilds, 2006; Sloan, 2010; Stuart, 2000) have shown that teachers may produce, increase, or reduce mathematics anxiety among students at all levels of schooling through their attitude and behaviour, teaching methods, and formal instructions/instructional strategies. Teachers who have mathematics anxiety have been shown to be less successful at conveying important mathematical concepts that are requisites for further academic growth to their students. Those teachers allocate less time to teaching these important concepts and use avoidance techniques in the classrooms (Dunkle, 2010; Hembree, 1990). Mathematics anxiety limits teachers' skills in doing or teaching mathematics as teachers with high mathematics anxiety often use traditional teaching methods, allocate more time for whole-class instruction and seatwork assignments, and less time for small-group instruction (Gresham, 2007a; Swars, Daane, & Giesen, 2006; Tobias, 1998). Overall, mathematics anxious teachers allocate less class time to teaching the subject concepts and problem solving strategies (Bush, 1989).

In addition, mathematics requirements for Canadian students majoring in elementary education are minimal (TEAS, 2012). Thus, one can pursue a career as an elementary school teacher despite having mathematics anxiety and a history of avoiding the subject. Some studies have shown that teachers who are anxious about mathematics are likely to be anxious about teaching mathematics (Hadley & Dorward, 2011) and that mathematics anxious teachers have lower levels of mathematics teaching self-efficacy (Bursal & Paznokas, 2006; Swars et al., 2006). When people who are anxious are in the position of teaching mathematics, their anxieties could be transferred to their students (Bekdemir, 2010; Brady & Bowd, 2005; Vinson, 2001). If the mathematics anxieties of these students are not addressed, some of them could take up teaching as a profession in the future and transmit their anxieties to their students, supporting the notion that mathematics anxiety in teachers and students could be cyclical in nature (Brady & Bowd, 2005; Smith, 2004). To address the re-occurring cycle of mathematics anxiety, it is imperative to conduct a thorough examination of the causes and effects of teachers' mathematics anxieties on their teaching practices, particularly those that manifest themselves in early grades in the school system. Such an examination could lead to creation of intervention strategies that could break the re-occurring cycle of mathematics anxiety.

While most studies on mathematics anxiety have been conducted with pre-service teachers (Bursal & Paznokas, 2006; Gresham, 2007a, 2009; Liu, 2008; Vinson, 2001), college students (Ashcraft & Kirk, 2001; Hembre, 1990; Iossi, 2009; Sheilds, 2006; Woodard, 2004), adolescents (Bernstein, Relly, & Cote-Bonanno, 1992; Khatoon & Mahmood, 2010; Miqdadi, 2006) and school children (Ma & Cartwright, 2003; Merrit, 2011), few studies have involved elementary school teachers (McAnallen, 2010; Hadley & Dorward, 2011). Even so, such studies usually focus on the nature of mathematics knowledge for teaching (Hart & Swars, 2009; Kajander, 2010) and put an emphasis on teachers' preparation to teach. However, as Johns, Schmader, and Martens (2005, p. 175) write, "Knowing [mathematics or how to teach it] is half the battle"—mathematics anxiety needs to be investigated as multifaceted and treated holistically (e.g., Berch & Mazzocco, 2007). Not only cognitive (e.g., attention, metacognition), but socio-cultural aspects (e.g., influences of gender, family, ethnicity, motivation) of mathematics anxiety among elementary school teachers in Canada need to be explored since the experience of mathematics anxiety may not be the same for every teacher due to differences in their past learning experiences and opportunities, cultural expectations, and social backgrounds. Taking a socio-cultural perspective of Lev S. Vygotsky (1896–1934), this thesis attempts to take into account not only individuals, but also the groups, and the society they belong to. In that way, both individualistic and holistic views of the phenomenon of mathematics anxiety are addressed.

Purpose of the Study

The purpose of this study was to examine the nature (levels, causes, and effects) of mathematics anxiety that exists among in-service elementary school teachers in Southern Ontario and how this anxiety differs by gender and other demographic factors, including socio-cultural. In addition, this study also examined the types of mathematics teaching anxiety experienced by in-service teachers and its relationship with mathematics anxiety. Socio-cultural factors included race and ethnicity, socioeconomic status, as well as influences of socializers, such as parents, teachers, counsellors, and peers whose attitudes and behaviours could influence individuals' beliefs, experiences, and decisions throughout their life.

Research Questions

In exploring mathematics anxiety among in-service elementary school teachers, this study sought to answer the following four research questions:

1) What are the levels of mathematics anxiety among in-service elementary school teachers and how do their anxieties differ in view of varied socio-cultural factors?
2) What are the types of mathematics teaching anxiety experienced by in-service elementary school teachers?
3) What is the relationship between in-service elementary school teachers' mathematics anxiety and mathematics teaching anxiety?
4) What are the self-reported causes of mathematics anxiety among elementary school teachers and what strategies did they use to cope with, diminish, or overcome it?

Personal Ground

My prior research with undergraduate female students in mathematics and physics departments investigated factors that influenced these students' decisions to pursue mathematics-related disciplines (Adeyemi, 2010). Participants in the study made connections between the elementary teachers' lack of subject knowledge and their anxieties when teaching mathematics; which in turn may have deterred some of their students from pursuing studies in the field. The findings from this study presented socializers, specifically parents and teachers, as influential on the females' decisions to pursue studies in mathematics fields. In particular, positive experiences provided by the teachers took the form of providing encouragement, using adequate teaching methods, and acting as role models at some points in these females' school years (Adeyemi, 2010). Based on the participants' recollections, these factors increased their interest in, enjoyment of, and fondness for mathematics and science. Thus, from a young age, teachers helped some of these females to develop positive attitudes toward mathematics and other sciences (Adeyemi, 2010).

As a female with a strong mathematics background, I have often wondered why it seems to be generally accepted in North America for individuals to make public confessions about "not being good in mathematics" as opposed to "not being good in reading." In addition, my research involvement with a School Board in Southern Ontario enabled me to witness, firsthand, confessions by elementary female teachers of not feeling at ease with mathematics contents, not enjoying mathematics and/or excelling in it when they were students. I have, therefore, pondered over the social and cultural influences that could be responsible for such confessions. Perhaps, these teachers' past experiences at home and in mathematics classrooms may be accountable for these confessions. In the light of this, my study explored why elementary school teachers experience mathematics anxiety, how it manifests itself (e.g., having levels of low, moderate, and high), how it affects their perceived teaching abilities, and what strategies some teachers used to cope with or overcome it.

Assumptions

This study was based on the assumption that participants would provide honest and accurate answers in the survey and give honest responses about their experiences regarding mathematics anxiety during interviews. It was my assumption that teachers would want to talk about their experiences with mathematics anxiety and that they would look forward to learning about my findings and recommendations as opportunities for them to reduce their anxieties (or those of their students) toward mathematics. Reduction in teachers' anxieties could, in turn, improve their students' achievement and attitudes towards mathematics. The assumption with respect to the two survey instruments that were administered in the study was that their reliability and validity, as reported in the literature, were accurate. That is, these instruments are valid and reliable instruments for measuring mathematics anxiety (its levels) and mathematics teaching anxiety (its types). In addition, this study was based on the assumption that mathematics anxiety is a disabling condition for which some teachers have developed strategies to cope (or perhaps overcome) in order to help students achieve at their full potentials in mathematics.

Significance of the Study

This study contributes to the body of research and knowledge on mathematics anxiety among elementary school teachers; it will point to various socio-cultural sources of mathematics anxiety. It will also make useful recommendations regarding how to prevent the transfer of mathematics anxiety to young girls and boys in the classrooms, as teachers will be made aware of issues related to mathematics anxiety, its types, levels and consequences, and their impacts on the students. The results of the study will inform policy makers, academics, and school boards, similar to those involved in the research, about how to meet the needs of elementary school teachers and other individuals who may be suffering from mathematics anxiety.

Limitation of the Study

The participants in this study were, specifically, grades 1 to 8 elementary in-service teachers. They were considered to be socio-culturally diverse. Although about 750 teachers in two school boards were invited to participate in the study, 111 teachers completed the survey and four took part in the interviews. Therefore, generalization of findings was limited to the target population. Another limitation was that the perceptions of students and other stakeholders (such as principals, parents, and policy makers) on elementary teachers' anxiety were not investigated in the study. Examining such perceptions could be insightful for the study.

Theoretical Framework

According to Maxwell (2005), the theoretical framework of a study is "the systems of concepts, assumptions, expectations, beliefs, and theories that support and inform research" (p. 33). This study draws on Vygotsky's (1981) sociocultural theory and Bandura's (1989) social cognitive theory. Sociocultural theory was used as a framework to understand the social and cultural factors that contribute to teachers' mathematics anxiety, while social cognitive theory was applied as the framework to understand the interplay of personal, environmental and behavioural factors, especially as they relate to the development of mathematics anxiety in individuals.

Sociocultural theory positions an individual in the specific historical, cultural, and institutional contexts. It concentrates on ways in which adults and peers impact the individual's learning, and ways in which cultural beliefs and attitudes affect how instruction and learning occur (Cerry, 2013). This theory was proposed by Vygotsky, who stated that:

> Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (Vygotsky, 1978, p. 57)

Vygotsky's theory accentuates learning as a process that begins in the social world and gets to the learner and not vice versa (Bonk & Kim, 1998). It also places emphasis on culture as crucial for further advancement in the development of an individual. Two types of concepts are produced as a result of learning that occurs inside and outside the classroom. These concepts are the individual's personal concepts (everyday, or spontaneous concepts) which are learned in daily life experiences through interactions with other individuals, and scientific (academic) concepts which are acquired from school (Haenen, Schrijnemakers, & Stufkens, 2003). Vygotsky viewed the two concepts as interdependent as everyday concepts set the foundations from which scientific concepts are learned. In a similar manner, the formation of scientific concepts influences and strengthens the understanding of everyday concepts. Jane and Robbins (2007) illustrated the connection between the two concepts when they argued that a learner will not readily comprehend scientific concepts such as ‘technical systems’ if she/he had not previously developed everyday concepts of things such as computers and switches or music boxes and levers. The learner's understanding of switches and computers, music boxes and levers changes when she/he learns scientific concepts. According to Vygotsky (1994), as cited in Haenen, Schrijnemakers, and Stufkens (2003), the everyday and scientific concepts are unified "into a single system of concepts formed during the course of the child's mental development" (p. 365).

Vygotsky's theory implies that social interaction is vital for learners to explore knowledge domains with their peers and adults in and outside the classrooms. He stated that "It is through others that we develop into ourselves" (1981, p. 161); which further emphasised the influences of others - peers, siblings, and adults - in the development of an individual. However, when any hindrance, such as feelings of anxiety, is experienced by peers, siblings, and adults, it disrupts the process of one's learning and also affects the individual's interaction with people in his/her environment (Wilder, 2012). Examining past experiences of individuals with mathematics anxiety, which include their interactions with socializers, and other social and cultural factors, would help provide better understanding of the social and contextual causes and development of mathematics anxiety.

On the other hand, social cognitive theory posits that individuals are neither driven by internal forces nor mechanically shaped and regulated by external stimuli (Bandura, 1986). This theory put forward a model of interactive agency where individuals learn through triadic reciprocal causation (Bandura, 1986). Specifically, Bandura explained that three reciprocal factors—personal (in form of cognition, affect, and biological events), behavioural, and environmental—interact with one another to influence individuals' beliefs and actions. These factors are not static or independent; rather, they operate as interacting determinants of each other. The ways in which these three factors interact is affected by human agency—a human's capacity to make choices and enforce those choices on the world (Bandura, 1989). When individuals make choices, these choices influence the environments into which they put themselves, the people with whom they decide to interact, and the behaviour in which they engage (Jameson, 2010). In explaining mathematics anxiety with Bandura's theory, personal factors include gender, race, and self-efficacy. Environmental factors include parents' and teachers' attitude towards mathematics and beliefs about mathematics and behavioural factors include mathematics avoidance.

In this study, factors such as parental influences were investigated, with parent's socioeconomic status and educational level taken into account, for better understanding of the complex phenomenon, mathematics anxiety. Also, sociocultural theory and social cognitive theory were chosen as frameworks, not to compete with each other but to reinforce one another. The environmental factor proposed by Bandura's (1989) theory encompasses Vygotsky's (1989) social and cultural factors, which influence individuals' learning and development through their interactions with adults and peers. An illustration on the reinforcement of the two theories is that the influence of a parent (Vygotsky's and Bandura's environmental factor) on the child's mathematics experiences could result in the child having low or high confidence in mathematics ability (Bandura's personal factor), which in turn could lead to mathematics avoidance or selection of advance mathematics courses and mathematics-related careers later in life (Bandura's behavioural factor). Findings from this study were interpreted in relation to both theories to determine the influences of various factors, such as socializers, on mathematics anxiety experienced by in-service teachers and to see whether these factors have reciprocal influences on one another.

Dissertation Outline

This dissertation is organised into five chapters. Chapter One contains the background and objectives of the study, presents the research questions and establishes the importance of the study. Chapter Two contains the review of literature pertaining to mathematics anxiety and mathematics teaching anxiety, and their association with demographic factors such as gender and race/ethnicity. The review of the literature on mathematics anxiety and mathematics teaching anxiety makes a case for the need for more studies in this area. Chapter Three contains a description of the research method and the rational for choosing sequential explanatory mixed methods design for the study. It also contains the description of the modification and translation of instruments that were utilised in the study as well as the methods of data collection and analysis. Chapter Four contains the results that were obtained from an analysis of the data collected through an online survey and follow up face-to-face interviews. Some results are presented with tables and figures and the emerging themes from the interviews are described. Chapter Five discusses the findings of the study in view of the literature and the theoretical framework as well as the implications for practice/recommendations, directions for future studies, and the limitations of the study.

Definition of Terms

Mathematics Anxiety: Is defined as the “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” (Richardson & Suinn, 1972, p. 551). This study employs the modified instrument which was originally developed by Richardson and Suinn; hence the adoption of this definition.

Mathematics Teaching Anxiety: Is defined as the teachers' feelings of tension and anxiety that happen in the course of teaching mathematical concepts, theorems, and formulas or problem solving (Peker, 2009). In this study, it will be described as the stress and anxiety that an elementary in-service teacher feels or experiences when teaching concepts related to mathematics.

In-Service Elementary Teachers: Are teachers who are currently employed in the school educational system and are teaching grades 1 to 8.

Socializers: Are parents, teachers, counsellors, and peers whose attitudes and behaviours could influence individuals' beliefs, experiences, and decisions throughout their life.

Self-efficacy: Is defined as “people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with the judgments of what one can do with whatever skills one possesses” (Bandura, 1986, p. 391). In this study, mathematics self-efficacy is defined as a person's judgment of their capabilities to solve mathematics problems.

Zone of proximal development (ZPD): Is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978, p. 86).

CHAPTER TWO

LITERATURE REVIEW

Studies on mathematics anxiety in the past 30 years have not only examined its dimensions, causes, and onset, but have also investigated its relationship with other constructs, such as test anxiety and self-efficacy (Hembree, 1990; Ho et al., 2000; Sloan, Daane, & Giesen, 2002; Swars et al., 2006; Zettle & Raines, 2000). Its association with gender, race, and age was also considered by some researchers (Balogˇlu & Kocak', 2006; Fuson, 2007; Hadfield & McNeil, 1994; Merritt, 2011). These studies were conducted with participants varying from primary students (Ma & Cartwright, 2003; Merritt, 2011) to secondary school students (Khatoon & Mahmood, 2010), and from pre-service teachers (Gresham, 2009; Liu, 2008) to in-service teachers (McAnallen, 2010). This literature review will take on five main areas:

i) the dimensions and consequences of mathematics anxiety;

ii) the relationship between mathematics anxiety and other anxieties;

iii) the possible causes of mathematics anxiety, including teachers as sources of mathematics anxiety and parental influences (parents' expectations, beliefs, socioeconomic status, educational levels) on mathematics anxiety;

iv) the connection between mathematics anxiety and teacher's mathematical content knowledge;

v) research findings on mathematics anxiety and gender; and

vi) research findings on mathematics anxiety and race/ethnicity

The Dimensions and Consequences of Mathematics Anxiety

Mathematics anxiety was proposed to have a two factor model that draws on the cognitive and affective dimensions (Bandalos, Yates, & Thorndike-Christ, 1995; Wigfield & Meece, 1988). Ho et al. (2000) described the cognitive component as the worry exhibited through negative expectations and self-deprecatory thoughts in anxiety-causing conditions, and the affective component as feelings of nervousness, tension, and fear experienced in anxiety situations. The existence of the two dimensions was explored in a comparative study by Ho et al. (2000), where the levels and dimensions of mathematics anxiety, as well as its association with mathematics achievement were examined in 671 Grade 6 students from three countries (i.e., China, the United States, and Taiwan). Data were collected through survey instruments—Mathematics Anxiety Questionnaire (MAQ) developed by Wigfield and Meece (1988) and Mathematics Achievement Tests developed by the researchers. Ho et al. (2000) used the confirmatory factor analysis to assess the measurement model of mathematics anxiety across the three countries and, afterwards, tested the structural model to investigate the relationship between affective and cognitive factors and mathematics achievement (that is, assessed both convergent and discriminant validity, and the predictive validity of the model). The findings revealed that, for all the three countries, distinct affective and cognitive dimensions of mathematics anxiety exist in Grade 6 students, with no statistically significant gender differences in mathematics achievement for all three national samples; there are no significant differences in the mathematics achievement mean scores between the Chinese (M = 23.40, SD = 6.26, n = 211) and the Taiwanese students (M = 22.56, SD = 6.22, n = 214), however the mean scores for both groups differ significantly from the mean score of United States students (M = 11.27, SD = 6.24, n = 246); and that there exist a negative relationship between the affective factor of mathematics anxiety and mathematics achievement of Grade 6 students from the three countries, with an indication that affective factor of mathematics anxiety, rather than cognitive, has a debilitating effect on student's mathematics performance. Also, Ho et al. (2000) reported that the path of cognitive factor of mathematics anxiety to mathematics achievement is not significant for Chinese and United States students but that it is significant for Taiwanese students and it could be a motivator for them. In the Ho et al. (2000) study, the affective and cognitive factors of mathematics anxiety seem to have different relations with mathematics achievement.

Other research on the cognitive dimensions of mathematics anxiety focussed more on the effects of mathematics anxiety on the cognition process, such as on the working memory. For example, Ashcraft and Kirk (2001) predicted that mathematics anxiety disrupts working memory processing when given a cognitive task that entails arithmetic or mathematics-related processes. They used a short form of the Mathematics Anxiety Rating Scale (MARS), developed by Alexander and Martray (1989), to measure the level of mathematics apprehension and anxiety in 66 undergraduate students of psychology. The authors also used the listening span (L-span) and computation span (C-span) tasks to measure participants' capacity and functioning of working memory. The findings showed that working memory capacity was negatively related to mathematics anxiety and that participants at higher levels of mathematics anxiety exhibited significantly lower working memory capacity scores (for L and C- span) when compared with those at lower anxiety levels. The authors concluded that mathematics-anxious students grapple with problems that entail even the simple but error-prone mathematics algorithms, such as borrowing, carrying, and long division, and that "mathematics anxiety disrupts the on-going, task-relevant activities of working memory, slowing down performance, and degrading its accuracy" (Ashcraft & Kirk, 2001, p. 236).

In a review of literature on mathematics anxiety, Ashcraft and Moore (2009) identified cognitive factors, such as inadequate motivation, low skill or ability in mathematics, and insufficient working memory, as the risk factors for mathematics anxiety that could lead to performance deficits and avoidance of the subject. The authors proposed that when a person's mathematics anxiety is aroused, it causes an "affective drop" (Ashcraft & Moore, 2009, p. 204), that is, a substantial deterioration in performance. Specifically, decline in performance occurs when a mathematics-anxious person is asked to do mathematics under timed, high-stakes circumstances. Hence, mathematics-anxious individuals are underestimated on their true ability in mathematics achievement and proficiency scores. By implication, the differences in mathematics achievement among students could sometimes be due to the mathematics anxiety that they experience rather than their varying levels of potential and ability. In conclusion, the authors stated that, since American society relies "on technology and current concerns over STEM (science, technology, engineering, and mathematics) training, anything that can be done to investigate, understand, and thereby prevent math anxiety is to be encouraged, beginning with promoting a sensitivity to its effects on students in the K-12 math classroom" (Ashcraft & Moore, 2009, p. 204-205).

Mathematics anxiety not only affects individuals' achievement in mathematics, but also their attitudes toward mathematics and their feelings about themselves. Individuals with high levels of mathematics anxiety have negative attitude towards mathematics which may lead to avoidance of mathematics throughout their schooling (Jameson, 2010). Along with a negative attitude to mathematics, a person with high level of mathematics anxiety has low mathematics self-efficacy (Cooper & Robinson, 1991). Levels of mathematics self-efficacy have been showed to be a strong predictor of mathematics performance among students (Pajares & Miller, 1994) as those who perceived themselves to do well in mathematics, and thus had high self-efficacy, displayed higher grades than those who had low self-efficacy (Bates, Latham, & Kim, 2011). Self-efficacious students engage more willingly in tasks, persist longer and work harder to accomplish challenging tasks, and experience fewer disturbing emotional reactions than those who harbour self-doubt about their capabilities (Bandura, 1997).

It is important to note that most of the studies that considered mathematics anxiety from cognitive dimensions and proposed a model such as *the working memory model* (Askcraft & Kirk, 2001; Beilock & Carr, 2005) throw more light on mathematics anxiety by providing a tenable explanation for the connection between mathematics anxiety and reduced mathematics performance in an individual. However, the model does not provide possible explanation for the underlying causes and onset of mathematics anxiety. Jameson (2010) argued that “In addition to knowing that mathematics anxiety occurs in children [as well as in adults], we need to examine the potential explanations for the existence of mathematics anxiety” (p. 49). Recognising that the examination of the cognitive aspects of mathematics anxiety is essential, this study aims at examining the social and cultural aspects of mathematics anxiety for an in-depth understanding of its onset, causes, and consequences on elementary in-service school teachers. In the next section, the connection between mathematics anxiety and other types of anxiety is discussed.

The Relationship between Mathematics Anxiety and Other Anxieties

Researchers (Ashcraft & Moore, 2009; Hembree, 1990) have shown that mathematics anxiety is related to, but distinct from test and trait state anxiety. Test anxiety is described as “an otherwise confident student’s state of panic during a test where self-doubt leads to a failure to realize potential in a testing environment” (Perry, 2004, p. 321), while trait anxiety is described as a person’s predisposition to worry. The relationship between mathematics anxiety and these two anxieties has also been found to vary by gender (Zettle & Raines, 2000). A meta-analysis by Hembree (1990) examined findings of 151 studies prior to 1990 on these relationships and found that mathematics anxiety correlated most strongly with test anxiety ($r = .52$, $p < .01$) and moderately with trait ($r = .38$, $p < .01$). In another study, Zettle and Raines (2000) used correlational and comorbidity analyses to examine the interrelationship among mathematics anxiety, trait, and test anxiety. The participants were 57 male and 134 female college students who registered for courses preparatory to college algebra and were anticipated to display higher levels of mathematics anxiety than other students. The researchers utilized three survey instruments, namely the State-Trait Anxiety Inventory, Form Y (STAI) developed by Spielberger, Gorsuch, and Lushene (1970); the Test Anxiety Inventory (TAI) developed by Spielberger (1977); and the Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn (1972). In their findings, Zettle and Raines reported a significant relationship amongst the three measures, with a much stronger relationship between mathematics anxiety and test anxiety than between mathematics anxiety and trait anxiety. Their study also showed that women had greater levels of mathematics anxiety, $F(1, 183) = 4.05$, $p = .04$, and test anxiety, $F(1, 183) = 10.47$, $p = .001$, than men; both men and women exhibited heightened trait and /or test anxiety through comorbidity analysis; and that, whereas women had more tendency to display comorbid test anxiety, men showed more trait anxiety.

This study shows that one size may not fit all and that a more holistic approach is needed when it comes to designing intervention programs for students with any form of anxiety. Similarly, Zettle and Raines (2000) concluded that the findings of this type of research would increase scientific understanding of mathematics anxiety, and could play a role in planning interventions that would help meet the needs of every college student that has mathematics anxiety.

Kazelskis et al. (2000) examined the relationship between mathematics anxiety and test anxiety in 177 women and 144 men enrolled in freshman college algebra courses. Among the participants that identified their ethnicity, 21.7% were African American, 70.9% were White, and 1.5% were Native American. The authors used three different instruments to measure mathematics anxiety and another set of three instruments to measure test anxiety. The findings revealed that correlations between the measures of mathematics and test anxiety were nearly as high as those within the measures (averaging about .5), thus making it difficult to conclude that the two constructs were separate. Results for men and women were similar on mean mathematics anxiety levels and the relationship between mathematics anxiety and test anxiety measures. However, Kazelskis et al. (2000) did not provide results on the differences or similarities that may exist due to participants' ethnicity.

The results from this study did not provide support for a clear distinction between the measures of mathematics anxiety and test anxiety. Rather, it illuminated the difficulty with measurement of mathematics anxiety and test anxiety. In order to further understand the concept and measurement of mathematics anxiety, the possible contributing factors are explored in the next section.

The Possible Causes of Mathematics Anxiety, Including Teachers as Sources of Mathematics Anxiety and Parental Influences on Mathematics Anxiety

Although research findings have been inconclusive in relation to the causes of mathematics anxiety (Mulenga, 1990), as "there is still no clear answer as to the nature and causes of this anxiety" (Balogˇlu & Kocak, 2006, p. 1331), researchers have identified several factors as possible causes of mathematics anxiety. These factors can be classified into three categories: environmental, intellectual, and personality. According to Hadfield and McNeil (1994), environmental factors include negative school experiences, parental pressure, insensitive teachers, and non-democratic and non-supportive class environment. Intellectual factors include negative attitude, low persistence, self-doubt, learning style, and lack of confidence in mathematical ability. Personality factors include reluctance to ask questions due to shyness, low self-esteem and gender bias. This section of the literature review focuses on environmental factors; in particular, teachers as a source of mathematics anxiety and parental influences on mathematics anxiety. The researcher chose to focus on these social groups (that is, teachers and parents) since they play a major role in the development of individuals (Gunderson, Ramirez, Levine, & Beilock, 2012) and in providing educational experiences to students (Geist, 2010). They also influence other environmental factors, such as the classroom and home surroundings.

Studies have shown that teachers may produce, increase or reduce mathematics anxiety among students at all levels of schooling through their attitude and behaviour, teaching methods, and formal instruction/instructional strategies. Also, there are indications that some teachers also possess mathematics anxiety (McAnallen, 2010; Zettle & Raines, 2000). The next paragraphs explore the teachers' influences on students' mathematics anxiety levels as well as elementary in-service and pre-service teachers' mathematics anxiety.

Teachers' influence on students' mathematics anxiety levels. For some students, the educational context at school could have an effect on their attitudes toward mathematics (Scarpello, 2007). In the early years of life, children develop ideas such as order and sequence, comparisons, and classifications that present foundation for more formal mathematics in the future, through interaction with both the surrounding environment and the adults in the environment (Geist, 2010). As they go through formal schooling, they may develop mathematics anxiety and negative attitudes toward mathematics when they encounter mathematics teachers whose ways of improving student's mathematical prowess and skills involve teaching methods that focus on i) getting the right answers rather than concept development; ii) repetition and speed, or "timed tests," rather than understanding; and iii) persistent emphasis on grades and unreal problem solving activities rather than those relevant to daily life (Geist, 2010; Harper & Daane, 1998; Popham, 2008; Scarpello, 2007). In addition, there are indications that mathematics anxiety is ingrained in teachers' teaching of mathematics and that it occurs in students more from the way the subject is presented to them or has been taught, than from the subject matter itself (Fiore, 1999; Stuart, 2000). Pre-service teachers in Sloan's (2010) study have stated that, in many situations, their former teachers were to blame for the inception of their anxieties toward mathematics as these teachers appeared harsh, unapproachable, and intimidating. In addition, Sloan identified the antecedents (sources) of mathematics anxiety among pre-service teachers as environmental factors, which included negative school experiences that could lead to negative attitudes towards mathematics, inadequate teaching methods of previous mathematics teachers, negative parental influences, and inadequate mathematics background; personality factors, which included lack of confidence; behavioural factors, which included avoidance of high level mathematics classes; and other factors, such as low mathematics achievement and test anxiety.

In another qualitative research study, Jackson and Leffingwell (1999) examined the kinds of instructor behaviour that produce or increase students' mathematics anxiety. The researchers also aimed at establishing when and how mathematics anxiety was experienced for the first time by 157 students enrolled in an elementary teacher education program in the United States. Data were collected through written responses to questions that asked participants to describe their "worst or most challenging mathematics classroom experience from kindergarten through college" (Jackson & Leffingwell, 1999, p. 583). These researchers found that of 157 participants, only 7% reported that they had positive experiences from kindergarten through college in mathematics classrooms. The participants' responses also revealed that they believed:

i) instructors' behaviours, overt (or observable) and covert (veiled or implied), were the cause of students' anxiety in mathematics classes. These include making derogatory comments about students in front of their peers, providing inappropriate or no feedback on students' questions, showing impatience when students ask for assistance, avoiding eye contact or proximity to students, and drawing attention to student errors in the presence of the whole class;

ii) instructors' uncaring attitudes, insensitivity, gender bias, and unrealistic expectations produced students' anxiety in mathematics classes;

iii) language and communication barriers between teachers and students (e.g., due to poor pronunciation by some instructors) and poor quality of instruction (e.g., poor explanation of the materials) were the causes of anxiety among the participants whose anxiety began in the freshman year at the college level.

Jackson and Leffingwell (1999) suggested strategies for instructors that could help them alleviate mathematics anxiety in students and anticipated that education would move towards the creation of a supportive environment that would guarantee students' success in learning mathematics. Their study not only linked mathematics anxiety to past experiences with mathematics instruction from kindergarten to college levels, but also brought to awareness the impact of instructors' behaviours and attitudes on students, starting from early years in school. Unpleasant past experiences that generally produce anxiety towards mathematics in students have been found to be largely caused by teachers' behaviour (Bekdemir, 2010). Such negative experiences with mathematics instruction in earlier grades could lead to low motivation and to development of negative attitudes toward mathematics that may last throughout one's life (Brady & Bowd, 2005; Harper & Daane, 1998). The limitation of the Jackson and Leffingwell (1999) study was that there was no gender breakdown for the participants who were elementary education majors. Also, the study did not provide any explanation on how the data that were collected by means of written responses were analysed and categorised into various themes.

Apart from studies in the United States, those conducted in other countries revealed similar findings on the effects of teachers on students' mathematics anxiety. For example, Brady and Bowd (2005) examined the level of mathematics anxiety, and past experiences with mathematics and level of formal mathematics education attained of 238 pre-service teachers (176 females, 62 males) who were enrolled in a compulsory course at a Canadian university. The Mathematics Anxiety Rating Scale (MARS) and an open-ended questionnaire, developed to find out about pre-service teachers' prior experiences with formal mathematics instructions at the elementary and secondary levels and their confidence to teach mathematics during their practicum, were used to gather data. Pearson correlation coefficients were calculated and emerging themes from the open-ended responses were noted. The findings revealed that: i) females' mathematics anxiety scores were significantly higher than the males'; ii) participants' prior experiences with formal mathematics instructions were related to mathematics anxiety, as participants indicated more enjoyment of studying mathematics in elementary grades than in secondary grades; iii) 33% of the participants were found to have undertaken formal mathematics instructions as far as grade 12, while only 11.8% studied mathematics beyond first year of university; thus, their highest level of formal mathematics instruction had a negative correlation to their total MARS score. The study established that lack of adequate preparation of pre-service and in-service teachers in mathematics could cause their feelings of apprehension when faced with the possibility of teaching or when they were teaching the subject. In addition, it was revealed that the pedagogical techniques that were used and the attitudes of the instructors toward students impacted the quality of participants' experiences with mathematics. Many of the participants felt that their mathematics education at the elementary and secondary levels had not prepared them to teach the subject confidently.

The lack of teacher preparation could have detrimental effects on the future of their students. The inability of teachers to teach confidently and effectively, particularly in elementary grades, would have potential negative consequences on the interest in and the performance of these students in mathematics at higher grades.

Another study which was conducted in Turkey, by Bekdemir (2010), explored how past negative experiences, particularly the worst experience and/or the most troublesome mathematics classroom experiences, related to and brought about mathematics anxiety in 167 senior elementary pre-service teachers (67 females and 100 males). This mixed method research utilized three instruments—Mathematics Anxiety Scale (MANX), Worst Experience and Most Troublesome Mathematics Classroom Experience Reflection Test (WMTMCERT), and Interview Protocol. The quantitative analysis of data from MANX and WMTMCERT showed that: i) the participants were generally in a moderate anxiety group, with 41% in the low mathematics anxiety category, 53% in the moderate mathematics anxiety category, and 6% in the high mathematics anxiety category and ii) there was a significant difference in anxiety levels between the participants with and those without bad experiences, with a higher anxiety level corresponding to having had a troublesome experience; and iii) the worst experience and most troublesome mathematics classroom experiences were not only directly related to the participant's mathematics anxiety, but were also the major causes of their mathematics anxiety.

The qualitative analysis of the interviews in Bekdemir (2010) revealed that past influences, related to negative experiences, resulted in mathematics anxiety among highly anxious pre-service teachers. Such influences include instructors' hostile behaviour towards these teachers when they had challenges solving mathematics problems, inadequacy of instructors characterized by the fast pace of teaching mathematics contents, peer pressure occurring when other students laugh at them over mathematics discussions, and school and surrounding context exemplified by family high expectations to be successful in mathematics. Teachers who taught these participants in the past were reported as being responsible for the causes of mathematics anxiety mainly through their behaviour and teaching approaches. The findings also showed that mathematics anxiety first appeared at grades 9 through 11, and that transition from the elementary and junior high school to high school level increased the percentage of students who had negative experiences.

Although Bekdemir's study established the persistence of mathematics anxiety among pre-service teachers, it did not explain how the levels of mathematics anxiety differed by gender among the participants. The study did not explore the effects of mathematics anxiety caused by past negative experiences on the teaching ability/efficacy of the pre-service teachers. Investigating mathematics anxiety in the Turkish context, where culture and learning environment differ from the Western context, broadens the literature; more so that most of the research in this area had been conducted in the Western context. In particular, Bekdemir (2010) claimed that there was no report of teachers' differential treatment of males and females among the participants in the interviews conducted. As we will see from some further literature, this is very much different from the research conducted in the United States and Canada.

Elementary in-service and pre-service teachers' mathematics anxiety. Teachers' mathematics anxiety was identified as one of the possible causes of mathematics anxiety in students. Researchers have asserted that a great percentage of elementary school teachers and pre-service teachers have high levels of mathematics anxiety (Bursal & Paznokas, 2006; Gresham, 2004, 2009; Levine, 1996; McAnallen, 2010; Sloan, Daane, & Giesen, 2002; Vinson, 2001; Zettle & Raines, 2000). In particular, Harper and Daane (1999), explain that "the elementary mathematics classroom might be considered as a beginning point for creating mathematics anxiety" (p. 29), as mathematics anxious teachers often transfer their fear and avoidance of mathematics to their students (Bekdemir, 2010; Furner & Berman, 2005; Hembree, 1990; Sloan et al., 2002; Tobias, 1998; Vinson, 2001; Zettle & Raines, 2000). Teachers' mathematics anxiety has been shown to have detrimental effects on the students' achievement and attitude towards mathematics. For example, Beilock, Gunderson, Ramirez, and Levine (2010) investigated whether female teachers' mathematics anxiety had an effect on female students' mathematics achievements. The sample of 17 first- and second-grade female teachers and 117 elementary students from 5 urban schools in the United States took part in the research. The short Mathematics Anxiety Rating Scale (sMARS) and the Woodcock–Johnson Test of Assessment were used to assess teachers' anxiety levels and students' achievement at the beginning and end of the school year. Also, the gender of the characters in the drawings that were produced by the students after being told two gender-neutral stories were used to assess their gender-related mathematics ability beliefs. By employing quantitative regression analysis, the authors found no differences in mathematics achievement between girls and boys at the beginning of the school year. However, at the end of the school year, female teachers' mathematics anxiety had negative effects on girls' mathematics achievement and on gender ability beliefs, but less so on boys'. In essence, the higher the teacher's mathematics anxiety, the lower the girls' mathematics achievement and the more girls agreed to the idea that boys were good at mathematics and girls at reading. The findings also reported that, at the end of the year, girls who embraced traditional gender ability beliefs (that is, those who perceived boys as good at mathematics and girls as good at reading) had significantly lower mathematics achievement than those who did not. These girls' mathematics achievement was also significantly lower than the boys' overall mathematics achievement at the end of the year. The authors argued that the differences discovered may be due, in part, to the fact that early elementary teachers were mostly females and that their high levels of mathematics anxiety corroborated the popular stereotype about girls' mathematics ability.

In their study, Beilock et al. (2010) did not compare the levels of anxiety of students to those of their teachers and the teachers' perceptions of their teaching. However, they emphasised that the current teachers' anxieties were not solely responsible for their female students' mathematics achievement and gender ability beliefs. Influences from previous teachers, parents, peers, and siblings, who may or may not display traditional academic gender roles, may contribute significantly to shaping girls' gender ability beliefs and affect their mathematics achievement.

In a recent study, McAnallen (2010) examined mathematics anxiety in elementary teachers and determined whether their mathematics anxiety has an effect on their mathematics teaching. McAnallen Anxiety in Mathematics Teaching Survey (MAMTS), which was developed by the author, was completed by 691 elementary teachers in rural, urban, and suburban communities from eight states in the United States. The findings revealed that 33% of the participants had higher levels of mathematics anxiety that resulted in reduced feelings of enjoyment of mathematics; 12% first experienced mathematics anxiety in the primary grades (K-2); 26% in elementary grades (3-5); 22% in middle school (6-8); and 40% later in their schooling years. In addition, participants who experienced mathematics anxiety in primary and elementary grades expressed that their teachers' teaching styles, and the various forms of ridicule, humiliations, and embarrassments they experienced contributed to their mathematics anxiety, while those who experienced it in middle and high school mentioned that the abstract teaching of algebra and geometry courses contributed to their mathematics anxiety. As well, lack of conceptual mathematical knowledge along with emphasis on rote memorization also contributed to mathematics anxiety at all levels. McAnallen's findings are consistent with those from other studies which asserted that mathematics anxiety does not originate from mathematics itself but rather from the way the subject is taught in school and may have been presented to teachers when they were children (Stuart, 2000).

Even though elementary teachers' mathematics anxiousness may affect their classroom teaching practices and their ability to teach mathematics effectively, there seems to be a lack of research that focuses on examining this relationship (McAnallen, 2010). However, this relationship is investigated among pre-service elementary teachers by some researchers (Bursal & Paznokas, 2006; Gresham, 2009; Swars et al., 2006). For example, Bursal and Paznokas (2006) explored mathematics anxiety levels and confidence levels to teach elementary mathematics and science in 54 female and 11 male pre-service elementary teachers in the United States. Three survey instruments—the Revised-Mathematics Anxiety Survey (R-MANX, developed by the authors), the Science Teaching Efficacy Belief Instrument, and the Mathematics Teaching Efficacy Belief Instrument—were used to collect data. The authors reported that the MTEBI survey showed that most pre-service teachers with low and moderate anxiety levels have confidence to teach mathematics effectively, while a substantial percentage (48%) of pre-service teachers with high mathematics anxiety level have no confidence in teaching the subject effectively.

Bursal and Paznokas (2006) also indicated that pre-service elementary teachers' mathematics anxiety influenced their self-efficacy beliefs about mathematics teaching and negatively affected their self-efficacy beliefs about science teaching. This was evident in the findings from STEBI instrument that showed that pre-service teachers with low mathematics anxiety are more confident to teach science effectively than those with moderate and high mathematics anxiety. This finding supports the idea that there is a connection between mathematics anxiety levels and one's confidence to teach mathematics and science. There is an indication that attitude towards mathematics could have a great impact on the attitude towards other subjects, such as science, for prospective teachers as well as for elementary and high school students (Bursal & Paznokas, 2006). However, the study did not examine or describe when and how attitudes towards mathematics and science interact. Neither did the authors differentiate their findings by factors such as gender, ethnicity, and race.

Furthermore, elementary pre-service teachers' efficacy at mathematics may be negatively affected by fear of mathematics brought about by bad past school experiences. In their study, Swars et al. (2006) examined the relationship between mathematics anxiety and mathematics teacher efficacy among 28 elementary pre-service teachers (26 females, 2 males) who were enrolled in undergraduate mathematics methods course in the United States. The perceptions of the participants' abilities and skills to teach mathematics effectively were also investigated. Data were collected by using MARS, Mathematics Teaching Efficacy Instrument (MTEBI), and individual interviews. The quantitative part of the gathered data was analysed by using Pearson product-moment correlation, while the qualitative part utilized grounded theory. The findings showed that there exists a moderately significant negative relationship between mathematics anxiety and mathematics teacher efficacy in elementary pre-service teachers. The teachers with lower mathematics anxiety not only had higher mathematics teacher efficacy, but also higher judgments of their abilities and skills to teach mathematics effectively. On the other hand, those with higher mathematics anxiety had lower mathematics teacher efficacy, and weaker perceived abilities and skills to effectively teach mathematics. Interview data revealed that pre-service teachers with a high level of mathematics anxiety associated negative experiences in the classroom, and the procedural way mathematics was presented to them, with mathematics anxiety. The teachers with low mathematics anxiety identified a parent as a role model in learning mathematics and shared past experiences that indicated reasoning, problem solving, and communication in relation to their relatively low mathematics anxiety level. However, despite the differences in their past experiences, pre-service teachers with low and high mathematics anxiety shared a common belief that effective teaching can result in students' learning of mathematics, irrespective of external factors. Swars et al. (2006) suggested that "providing a self-awareness of negative experiences with mathematics may be a building block towards reducing mathematics anxiety and increasing mathematics teaching efficacy" (p. 313).

It is worth noting that this study was based on a small sample. An extension of this study to a larger sample with different demographical and socio-cultural contexts, could throw more light on the effect of mathematics anxiety on the teachers' self-efficacy beliefs and perceived effectiveness to teach mathematics.

In addition to the connection between mathematics anxiety and self-efficacy beliefs, some researchers (Ertekin, Dilmac, & Yazici, 2009; Gresham, 2007b; Sloan et al., 2002) have suggested that pre-service teachers' mathematics anxiety levels are related to their learning styles. For further clarification of this relationship, Sloan et al. (2002) paired the learning styles of 61 elementary education majors and 11 special education majors with their mathematics anxiety levels to find a correlation between mathematics anxiety and learning styles. Data were collected with two instruments—the MARS and the Style Analysis Survey (SAS). A low significant positive correlation ($r = .28$, $p < .05$) was found between the "global learning style" and mathematics anxiety. Sloan et al. (2002) explained that global learners (also referred to as the right brain learners) are more inclined to "approach problems in an intuitive manner, whereas most mathematics courses are taught through systematic problem solving in a step-by-step linear fashion" (p. 86). Other studies reported prevalence of mathematics anxiety among tactile-kinesthetic learners (McCoy, 1992), as well as positive correlation between mathematics anxiety and auditory learning style (Onwuegbuzie, 1998).

Additionally, Ertekin, Dilmac, and Yazici (2009) examined the connection between mathematics anxiety and the learning styles of 293 trainee teachers enrolled at the primary and secondary mathematics education department in Turkey. They also questioned the extent by which a teacher trained in a traditional manner would be able to implement teaching activities that are in line with new methods of teaching that promote learning by doing. Data were collected with the Mathematics Anxiety Scale (MAS, developed by Erktin, Dönmez, &

Özel, 2006), and the Marmara Learning Styles Scale (MLSS, developed by Otrar, 2006), and were analysed by calculating the Pearson Product Correlation Coefficients of the scores from the sub-dimensions of the two scales. The researchers found varied correlation coefficients (-0.242 to 0.302) that revealed a generally weak correlation between the MLSS and the MAS sub-dimensions. Specifically, Ertekin, Dilmac, and Yazici (2009) reported that only the mathematics testing and evaluation sub-dimension of the MAS and the authority sub-dimension of the learning-styles scale had a relatively stronger relationship (i.e., .30), compared to other dimensions. The findings also revealed that whereas there was no relationship between anxiety towards the mathematics lesson (a sub-dimension of MAS) and auditory and social interaction (sub-dimensions of MLSS) learners among the trainee teachers, there exist higher levels of anxiety towards the mathematics lesson among tactile and visual trainee teachers when compared to other sub dimensions. This, perhaps, implies that the teaching activities are planned in such a way that they exclude visual and tactile learners, thus reinforcing that a traditional teaching method is prevalent. Ertekin, Dilmac, and Yazici concluded that mathematics taught in relation to the tactile and visual sub dimensions of learning styles would help in reducing mathematics anxiety. The insight from the studies that address mathematics anxiety and learning styles is that a teacher who teaches only in relation to his/her learning style may create problems that could have negative effects, in attitude or anxiety, on students with differing learning styles.

Furthermore, mathematics anxiety and its relationship with mathematics teaching anxiety among teachers have been studied by some scholars (Brown, Westenskow, & Moyer-Packenham, 2011; Hadley & Dorward, 2011). Mathematics teaching anxiety differs from mathematics anxiety in that it centers on a person's anxiety about his/her ability to teach mathematics, tends to be more externally directed, reveals the individual's perceptions of his/her ability to engage students in any dealings with mathematics, and may not depend on a person's mathematics knowledge. On the contrary, mathematics anxiety tends to be more internally directed, reveals an individual's perceptions of their ability to interact with mathematics, and may depend on individual's mathematics knowledge (Brown et al., 2011).

Most of the studies that looked into mathematics anxiety alongside mathematics teaching anxiety focussed on pre-service teachers and generally, their results were inconsistent. For example, Hadley and Dorward (2011) investigated, among other things, the connections between elementary teacher anxiety about mathematics, anxiety about teaching mathematics, student mathematics achievement, and mathematics instructional practices. The participants were 644 female and 48 male elementary school teachers from grades one to six in the western United States. The modified Mathematics Anxiety Rating Scale-Revised, adapted by Hopko (2003), was administered to measure teachers' mathematics anxiety. In addition, Hadley and Dorward (2011) created a new instrument from the modified MARS-R that emphasized teaching mathematics and used it to measure teachers' anxiety about teaching mathematics. By using Pearson correlation, the authors found a positive relationship ($r = .42$, $p < .001$) between anxiety about mathematics and anxiety about teaching mathematics; thus indicating that teachers who are anxious about mathematics are likely to be anxious about teaching mathematics. However, Hadley and Dorward (2011) reported that: i) some elementary teachers with higher levels of mathematics anxiety had an increase in mathematics teaching anxiety while others showed moderate or low anxiety about teaching mathematics; ii) as mathematics teaching anxiety increases, student mathematics achievement reduces; and iii) there exists no relationship between teachers anxiety about mathematics in general and student mathematics achievement.

Brown et al. (2011) conducted a study to show that the relationship between mathematics anxiety and mathematics teaching anxiety is unpredictable. These researchers challenged the notion that high levels of mathematics anxiety from past experiences would result in high levels of mathematics teaching anxiety (and vice versa) by investigating the rate of occurrence of the relationship between elementary pre-service teachers mathematics anxiety from prior experiences and mathematics teaching anxiety among 53 elementary pre-service teachers. Data were collected through written reflections on background experiences and classroom experiences after the participants taught at least three elementary mathematics lessons in schools during their practicum. In the data analysis, each participant’s file was handled as a case. The 53 cases were coded, classified, and clustered into four groups. Brown et al. (2011) found that, while 21 (39.6%) of the participants reported no experience of both mathematics anxiety and mathematics teaching anxiety, 11 (20.8%) reported experiencing both mathematics anxiety and mathematics teaching anxiety. In addition, 10 (18.9%) participants claimed that they experienced mathematics anxiety without mathematics teaching anxiety, while 9 (17.0%) reported having mathematics teaching anxiety, without mathematics anxiety. Brown et al.’s (2011) findings indicated that mathematics anxiety and mathematics teaching anxiety are two distinct constructs that deserve further investigation since “…teachers with low or no mathematics anxiety in their past experiences can still possess mathematics teaching anxiety when teaching mathematics to students” (p. 11), which in turn may have a damaging effect on students’ experiences and achievement in mathematics. Thus, understanding mathematics anxiety among in-service teachers and its influences (if it does have) on their mathematics teaching anxiety is worthy of investigation.

Parental influences on mathematics anxiety. Parents' expectations, beliefs, encouragement, attitudes and behaviours, may have a positive or negative effect on children's feelings, participation, and fondness of mathematics. Some parents are good at mathematics and set very high expectations for their children in mathematics. They push their children to succeed in the subject by tutoring them and, sometimes, by comparing them with other siblings or peers who excel in mathematics. The negative consequences of parents' high expectations in mathematics are that the child may become anxious about mathematics (Bekdemir, 2010) and decide to take as little mathematics as possible (Arem, 2003) when trying to meet these expectations. However, a contrary result was found in the *Programme for International Student Assessment* (PISA) test administered to about 28 million of 15-year-old students in 65 countries/economies, including the U.S.A., Canada, Mexico, and most of Europe, to measure students' achievements in reading, mathematics, and science. The test, administered by *Organisation for Economic Co-operation and Development* (OECD, 2012), focused mainly on students' achievement in mathematics, with reading and sciences as minor areas of focus. The result showed that students whose parents had higher expectations for them seemed to report more persistence, higher intrinsic motivation to learn mathematics, and more confidence in their abilities to solve mathematics problems than students whose parents had lower expectations for them. Differences in motivation, perseverance, and confidence were noted between the two groups of students having similar background and academic performance.

Apart from having high expectations for their children in mathematics, some parents stereotype mathematics as a male domain and believe that boys are better in mathematics than girls. For example, Tiedemann's (2000) study with grades 3 and 4 students (n = 600) found that parents who endorsed strong mathematics gender stereotypes believed that their sons had higher mathematics ability than their daughters, and that the ability beliefs held by parents predicted the children's self-perceptions about their mathematical ability. Parents also make attributions about success in mathematics in such a way that boys' success in mathematics is attributed to innate ability, while girls' success is attributed to great effort (Sheilds, 2006); implying that the success of boys in mathematics is due to natural talents while girls' success is a result of hard work (Gunderson et al., 2012). Differing attributions to achievement in mathematics by parents could result in boys frequently getting preferential treatment during mathematics time (Geist, 2010).

Furthermore, parents are likely to provide more encouragement and mathematics related activities for their sons than for their daughters, resulting in deferential treatment of boys and girls. According to Gunderson et al. (2012), differential treatment by parents could be social in nature (e.g., girls are ridiculed when they ask for help) or it could be cognitive in nature (e.g., boys are given more difficult mathematics question to solve, which in turn could result in boys performing at high levels in mathematics). Parents also provide their sons with more opportunities to get involved in sports and computing, whereas they give their daughters more opportunities to read and mingle with friends (Eccles, 1994). In a similar manner, females experience more nurturing and restrictions from parents, whereas males experience more parental interventions and engagements outside the home (Muller, 1998).

In their study, Jacobs, Davis-Kean, Bleeker, Eccles, and Malanchuk (2005) investigated the nature of mathematics/science opportunities and expectations that parents provide for their daughters and sons. Using the data from the longitudinal *Childhood and Beyond (CAB)* study that included 864 children and 550 parents, Jacobs et al. (2005) found that parents seem to give more mathematics-supportive environments for boys than girls, as they buy more mathematics and science toys for boys and spend more time on mathematics/science activities with them.

Parents also have higher perceptions for boys' mathematics abilities than those of girls and are less likely to create an environment that is mathematics-supportive or mathematics-promotive for girls. Jacobs et al. concluded that "the achievement environment in many homes is a gendered environment and messages from parents about achievement continued to be sent through gender-typed filters" (p. 260).

It is important to note that little research has examined the influences of parents' educational levels and SES on mathematics anxiety. One of such studies was done by Alexander and Martray (1989) with 517 college students. Alexander and Martray found that students whose mothers' highest educational level was high school had higher levels of mathematics anxiety than those whose mothers had higher degrees. They also reported that students whose fathers were manual workers had higher levels of mathematics anxiety than those whose fathers were professionals. However, researchers have reported that parents' educational levels and SES could influence students' achievement and participation in mathematics (Catsambis, 2005; Ercikan, McCreith, & Lapointe, 2005; Muller, 1998). According to Catsambis (2005), parents who are highly educated and are of higher SES are capable of providing extra learning opportunities in academic subjects, including mathematics, for their children both at home and in school. Wilson and Ma (2003) also reported that students whose parents are more educated seem to maintain more positive feelings and higher perceptions of the usefulness of mathematics throughout their high school years than those whose parents are not as educated. Perceived usefulness of mathematics brings about a difference in anxiety levels between male and female students (Shields, 2006).

In another study, Ercikan et al. (2005) used data collected from three countries—Norway, Canada and the United States of America—to examine factors that relate to males' and females' mathematics achievement and participation in advanced mathematics courses. The participants in the study comprised large samples of senior secondary school students from the three countries (Canada, *n* = 5,232; USA, *n* = 5,807; Norway, *n* = 2,518). Ercikan et al. found that: i) parent's highest educational level was the strongest predictor of achievement for the USA students, whereas for students in Canada and Norway confidence in learning mathematics strongly predicted their achievement; ii) students' attitude towards mathematics was the strongest predictor of participation in advanced mathematics courses for students in the three countries; iii) SES, parents' highest educational level, and home support for learning were strongly related to mathematics achievement for Canadian female students and all the students from the USA; and, iv) there was the likelihood that lower SES background may negatively affect female students more than male students in all the three countries.

Ercikan et al. (2005), Jacob et al. (2005), and Muller (1998) studies, highlighted the influences that parents have on their children in the learning of mathematics. Parents need to encourage their daughters and sons in mathematics, communicate positive messages to them, and promote the usefulness of mathematics for future educational and occupational success. More research is needed to explore the effects of parents' educational levels and SES on mathematics anxiety as they remain unclear. However, substantial literature explores connections between the teachers' content knowledge of mathematics and their mathematics anxiety.

Teachers' Mathematics Content Knowledge

There are indications that many teachers do not have profound mathematics content knowledge (or mathematical understanding) as their occasions to learn mathematics have been inconsistent and mostly insufficient (Ball, Hill, & Bass, 2005). Although there are some outstanding mathematics teachers at the Primary/Junior/Intermediate levels, deep understanding of the materials that would help students perform at the highest levels in mathematics is uneven among the teachers (Kajander, Kotsopoulos, Martinovic, & Whiteley, 2013). Teachers' knowledge of the content determines the quality of mathematics teaching and the teachers' abilities "to use instructional materials wisely, to assess students' progress, and to make sound judgments about presentation, emphasis, and sequencing" (Ball et al., 2005, p. 14). Lack of adequate knowledge of mathematics in combination with mathematics anxiety, make teachers' abilities to deliver sound mathematics instruction to their students questionable.

Other research reported that many teachers at the elementary and high school levels do not necessarily have strong academic backgrounds in mathematics (Education Quality and Accountability Office (EQAO), 2001; Ingersoll, 1999; McAnallen, 2010) and that the awareness of limited mathematical knowledge could arouse mathematics anxiety in teachers (Hoff, 2001; Ma, 1999). For example, in Canada (specifically in Ontario), the percentage of university mathematics degree holders among mathematics teachers of Grade 9 applied course level (non-university bound) and the academic course level (university-preparatory) are 34% and 41% respectively (EQAO, 2001). One could then suggest that teachers' highest level of formal mathematics education could be related to their anxiety levels, as the highest level of formal mathematics education was reported to correlate negatively with pre-service teachers' mathematics anxiety scores ($r = -.28$, $p < .01$) (Brady & Bowd, 2005).

In a more recent report, EQAO (2014) revealed that Grade 3 and 6 students met the provincial standard in reading and writing skills while their standard in mathematics decreased. In this report, 67% of Grade 3 and 54% of Grade 6 students met the provincial standard in mathematics in 2013/14. These percentages have dropped when compared with 71% of Grade 3 and 61% of Grade 6 students who met the standard in 2009/10. According to the Ontario

Education Minister, Liz Sandals (as cited by Alphonso & Morrow, 2013), the decrease in students' performance in mathematics could be associated with elementary teachers' weak academic background in mathematics. In order to resolve this situation, the Minister declared the need to help teachers feel more comfortable with teaching mathematics through professional development. This type of professional development is aimed at "helping teachers become comfortable in teaching the mathematics curriculum by gaining a deep understanding of the concepts they teach" (Hadley & Dorward, 2011, p. 40).

In the United States, teachers' lack of mathematics content knowledge also exists as 26.5% of Grade 7 to 12 mathematics classes have teachers who are teaching mathematics out-of-field. (Ingersoll, 1999). The above stated concerns led researchers to propose a variety of remediation strategies including the requirements that (i) teachers need to study more mathematics through enrolment in additional coursework; (ii) future pre-service teachers need to possess at least one undergraduate course (if possible two courses) in mathematics before admission to Primary/Junior/Intermediate teacher education (Kajander et al., 2013); and (iii) pre-service teachers receive adequate preparation through mathematics methods courses offered by teacher education programs (Gresham, 2007a, 2009; Harper & Daane, 1998; Swars, Daane, & Giesen, 2006; Vinson, 2001). Some strategies, particularly those that aim at reducing mathematics anxiety in teachers (mostly pre-service teachers) and providing better understanding of mathematical concepts, involve the use of children's literature and manipulatives in the mathematics classrooms, as well as the teaching of certain mathematics terminology (Sherman, Richardson, & Yard, 2009; Ward, 2005). For example, Vinson (2001) investigated the changes in the level of mathematics anxiety in 87 pre-service teachers who were enrolled in a mathematics methods course through the use of Bruner's framework (which emphasises the development of conceptual knowledge before procedural knowledge) and manipulatives. Mathematics Anxiety Rating Scale (MARS) and questionnaire-guided narrative interviews were used to gather data from participants before and after the end of a quarter. The study revealed that, at the end of the course, the overall mathematics anxiety of the participants was significantly reduced. While the anxiety of some participants increased due to lack of familiarity with the manipulatives, other participants indicated that the presentation of mathematics in pictorial and concrete forms helped them understand the mathematics concepts and procedures.

Similar to Vinson's work, Gresham (2007a) examined the levels of mathematics anxiety in 246 early childhood/elementary pre-service teachers and whether their mathematics anxiety could be reduced after participating in a mathematics methods course that involved the use of manipulatives and Bruner's model of concept development. Utilizing a mixed method approach, Gresham (2007a) reported a significant reduction in the overall pre-service teachers' mathematics anxiety. The participants in Gresham's study attributed the reduction in their anxiety level to the use of manipulatives adopted in the course, the personality of the professor and the inviting atmosphere created by the professor, and the use of journal writing throughout the course. Most of the participants remarked that "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, 2007a, p. 186). Gresham concluded that pre-service teachers' understanding of mathematics concepts and procedures would help them teach more effectively; this in turn could help prevent or reduce mathematics anxiety in their future students.

The research conducted by Vinson (2001) and Gresham (2007a) reiterates the fact that educators have an influence on the students' anxiety levels and that addressing mathematics anxiety in pre-service teachers (as well as in-service teachers) could lead to quality mathematics instruction in schools. Comparison of levels of anxiety between male and female pre-service teachers was not discussed in any of these studies since the participants were mostly females.

Furthermore, Dunkle (2010) examined the level of mathematics anxiety among 56 pre-service elementary teachers to determine whether remediation techniques would reduce their level of mathematics anxiety within a short period of time rather than a whole quarter or semester as in other research. The RMARS was used to collect data during three consecutive classes and the pre- and post- treatment RMARS score patterns were analysed to determine the amount of change in the participants' mathematics anxiety resulting from remediation treatment. Dunkle incorporated the use of children's literature, mathematics manipulatives, practice lessons, familiarity with a specific education standard, and understanding of mathematics vocabulary as treatment in her study. In her findings, she reported a statistically significant reduction in participants' level of mathematics anxiety due to the treatment methods over a short period of time.

One of the limitations of Dunkle's (2010) study is that the demographic information about the participants was not provided and comparison of findings (that is the reduced mathematics anxiety among participants) in relation to other variables such as gender, age, race was not reported. It is unclear whether the participants were homogenous or heterogeneous groups and, perhaps, whether the absence or presence of other variables could have influenced the results of the study. Although the findings from Vinson (2001), Gresham (2007a), and Dunkle (2010) ultimately show that mathematics methods courses may reduce perceived mathematics anxiety in pre-service teachers, further research is needed to examine whether the reduced level of mathematics anxiety in pre-service teachers persisted and translated into effective mathematics teaching in their various future classrooms (Dunkle, 2010). Since most elementary pre-service and in-service teachers are females, it is important to provide a review of the literature on mathematics anxiety and gender.

Mathematics Anxiety and Gender

Studies that have investigated mathematics anxiety and gender differences have reported inconsistent findings. However, the notion that mathematics anxiety affects females more than males seems to be popular and evident in research findings that involve students, adults, and teachers. Female students are said to have higher mathematics anxiety than their male counterparts (Alexander & Martray, 1989; Altermatt & Kim, 2004; Balogˇlu & Kocak, 2006; Fuson, 2007; Hadley & Dorward, 2011; Hembree, 1990; Ho et al., 2000; Khatoon & Mahmood, 2010; Ma & Cartwright, 2003; Merritt, 2011; Muqdadi, 2006; Woodard, 2004), which may be due to social and motivational factors. For example, Altermatt and Kim (2004) argue that there is an obvious difference in the level of anxiety experienced by males and females, and that females' heightened anxiety seems to put them at a disadvantage. By focussing on the gender differences during the college entrance exams, Altermatt and Kim proposed three theories as the reasons why females worry about/during exams more than their male counterparts. First, unlike males, females may believe that poor performance is caused by uncontrollable factors such as low ability. This may result in concerns that low scores indicate that they lack the skills that are essential to succeed and that they have little likelihood to improve these skills. Second, females may be more concerned about not disappointing the significant others in their lives, including parents, teachers, and counsellors. Thus, pressure over doing well in exams, and at the same time over pleasing others, may produce high levels of anxiety in these females, which may in turn affect their performance. Third, females may worry more in a competitive environment since they are socialized to be cooperative as a group. Thus, if females perceive the aim of the college entrance exams as an opportunity to compete for access to high-status colleges and to limited scholarship funds, then, they may be at a disadvantage because of the way they are socialized. Altermatt and Kim concluded by suggesting ways to reduce females' anxiety and advocated for the implementation of pragmatic policies by parents, teachers, and counsellors that would reduce females' worry and prepare them for future challenges in college and workplace.

In their study, Ma and Cartwright (2003) used data from the Longitudinal Study of American Youth (LSAY) to investigate the rate of change in mathematics affect (i.e., the construct encompassing attitude towards mathematics, anxiety towards mathematics, and utility of mathematics) of 1,626 male and 1,490 female students across middle and high school. The authors found that for both male and female students, there was not only a decline in attitude towards mathematics and utility of mathematics, there was also growth in anxiety towards mathematics from middle to high school grades. Also, the female students' anxiety towards mathematics grew significantly faster than males. Ma and Cartwright argued that as soon as mathematics anxiety arises in females, it not only impacts their performance at that moment, but also has an effect on them throughout their years in school. Thus, if mathematics anxiety in individuals is not addressed, it could lead to avoidance of mathematics and mathematics phobia (Tobias, 1978).

In another study, Balogˇlu and Kocak (2006) examined the relationships among age, gender, and mathematics anxiety after adjusting for differing mathematics experiences among 759 college students enrolled in classes in nine different departments in a university in the United States. Data were collected with the Revised Mathematics Anxiety Scale (RMARS) that contains three subscales (i.e., Mathematics Test Anxiety, Numerical Task Anxiety, and

Mathematics Course Anxiety) and a demographic information sheet. The overall RMARS scores showed that female students had higher anxiety scores than males, and that their mathematics test anxiety scores were also higher than those of the males. On the other hand, the male students’ numerical task anxiety scores were significantly higher than the females’. This implied that, whereas females experienced more mathematics anxiety in evaluative situations than males, their male counterparts experienced higher mathematics anxiety when doing basic mathematical calculations such as multiplication or division. In addition, the findings on age differences not only showed that older students scored higher than the younger ones, but also that the older and younger students experienced mathematics anxiety differently in mathematics courses. Balogˇlu and Kocak indicated that, in older students, evaluative situations related to mathematics or enrollment in mathematics courses seemed to provoke more anxiety, while in younger students getting involved in basic mathematical activities, such as multiplication, seemed to provoke more anxiety. Fuson (2007) reported a significant difference in mathematics anxiety between males and females with male scores significantly higher than female scores on the three composite variables considered (self-confidence, enjoyment, and motivation). As a result, Fuson indicated that mathematics anxiety is predictable by the gender of the learners. Muqdadi (2006) also found that high school female students in the United States scored significantly higher than their male counterparts, with a mean difference of 25.15, when their mathematics anxiety scores were compared. Hadley and Dorward (2011) reported that, although in-service male teachers had lower mathematics anxiety compared to their female colleagues, their anxiety did not result in lower mathematics teaching anxiety.

Contrary to these research results, Gierl and Bisanz (1995) found no gender differences in mathematics anxiety among Grade 3 and 6 students. Merritt (2011) found no statistically significant difference in the measure of mathematics anxiety between Grade 7 boys and girls in one middle school in the United States. Also, Ho et al. (2000) found no gender differences in mathematics anxiety between boys and girls in China, but found that girls have higher mathematics anxiety than boys both in the United States and Taiwan. Perhaps there are cultural and social influences that account for the stated differences in mathematics anxiety among these students. Haynes, Mullins, and Stein (2004) examined the causes of mathematics anxiety in undergraduate students and found no significant differences in the mathematics anxiety experienced by males and females. Hembree's (1990) meta-analysis of 151 studies that included gender differences in 9,209 college level students found that females displayed higher levels of mathematics anxiety than males, with a mean effect size of .31($p < .01$). However, Hembree reported that for females, the higher levels of mathematics anxiety did not seem to translate into reduced performance or to greater mathematics avoidance, whereas high school males displayed more negative behaviours that relate to mathematics anxiety than their female counterparts.

In their study, Khatoon and Mahmood (2010) investigated the relationship between mathematics anxiety and gender, school types, and achievement in mathematics. The participants were 1,652 pupils of which 863 (52.24%) were males and 789 (47.76%) were females from 15 secondary schools in the largest state in terms of population in India. The authors developed and applied Mathematics Anxiety Scale (MAS) and Mathematics Achievement Test (MAT) instruments. Pearson Product Moment Technique was used to assess the correlation between mathematics anxiety and mathematics achievement scores, and a *t*-test was utilized for testing the difference between mean scores of mathematics anxiety with respect to gender, and types of schools and mathematics achievement. Regarding mathematics anxiety and gender, Khatoon and Mahmood reported that nearly half of the secondary school students had a moderate level of anxiety and that females displayed more anxiety toward mathematics than their male counterparts.

Yazici and Ertekin (2010) took a different approach to gender differences by examining mathematics teaching anxiety and mathematical beliefs of 207 female and 83 male prospective elementary teachers in Turkey. Data were gathered with two instruments—the Mathematics Teaching Anxiety Survey (MATAS) containing four sub-categories and the Beliefs About Mathematics Survey (BAMS) containing three sub-categories. The results revealed that the females experienced more mathematics teaching anxiety than the males, which was due to subject knowledge and self-confidence. However, the researchers found no statistically significant difference between males' and females' mathematics teaching anxiety due to attitude towards teaching mathematics and subject teaching knowledge. Also, the results showed a significant difference ($t = -2.697$, $\alpha < .05$) in the sub-category of beliefs about the process of learning mathematics between prospective male and female teachers, with the males' mean score higher than the females'; suggesting that males had more instrumentalist viewpoints regarding the learning of mathematics (than females) as they believed, for example, that mathematics comprised of rules that have to be memorized and that mathematics could only be learnt from teachers. However, there appears to be no significant differences in the sub-categories of beliefs about the use of mathematics and nature of mathematics between the two groups (males versus females). In conclusion, the authors suggested "in-depth investigations into the reasons of gender differences encountered in the variables of both mathematical beliefs and mathematics teaching anxiety in future qualitative research" (p. 613). The results presented here suggest that gender differences in mathematics teaching anxiety between males and females vary; thus implying a complex phenomenon.

Detecting and tackling mathematics anxieties in the early grades can possibly prevent more serious difficulties in the later grades (Vinson, 2001). Avoidance of mathematics anxieties in early grades relies mostly on elementary teachers whose roles are to develop and foster elementary students' mathematics skill and confidence in the subject. If these teachers were to make mathematics more relevant and exciting for their students, they may need to develop better understanding of mathematics and deal with their anxieties or negative attitudes that, if left untreated, may negatively impact their teaching. Thus, research with in-service teachers in early grades would help throw more light on the causes of their mathematics anxiety and its impact on their teaching so that strategies (such as additional professional development and training) could be implemented that would help reduce or eliminate their mathematics anxiety. This, in turn, could encourage in-service teachers to seek out and adopt curricular alternatives that could help reduce mathematics anxiety in their students.

Mathematics Anxiety and Race/Ethnicity

Research into mathematics anxiety as it pertains to race and ethnicity is limited in the literature (Alexander & Martray, 1989; Hembree, 1990; Ma, 1999; Merritt, 2011). A few research projects that explored mathematics anxiety and its relationship with race and ethnicity reported inconsistent findings. For example, Hembree (1990) found five studies where Black and White college students' (n = 804) mathematics anxiety scores were compared and indicated that: i) there was no statistically significant difference in the mean effect size in comparing mathematics anxiety of Black and White college students and ii) Hispanic students appeared to be more anxious than White students (mean effect size = .82, p < .01) and Black students in two out of the five studies that were compared. Osborne (2001) found that White students' anxiety scores were lower than the non-White students. A similar finding was reported by Merritt (2011) whose study with Grade 7 students revealed that, although White students' mathematics anxiety mean score (M = 195.01) was lower than Black students' mathematics anxiety mean score (M = 206.35), there was no statistically significant difference in the levels of mathematics anxiety between White and Black students.

Berstein et al. (1992) also reported that race was greatly associated with the feelings of mathematics anxiety among 1,152 students in vocational-technical and comprehensive schools in New Jersey. The researchers found that high levels of mathematics anxiety existed in African American, Hispanic, Asian, and Native American male students and African American and Hispanic female students. In addition, their findings showed that male students in Asian and Native American groups exhibited higher mathematics anxiety than their female counterparts, whereas the feelings of mathematics anxiety were similar among male and female African American and Hispanic groups. Berstein et al. (1992) concluded that programs intended for the alleviation of mathematics anxiety need to start from the elementary school years. Such programs, I would suggest, should include not only the elementary students but also their classroom teachers.

Muqdadi (2006) compared the mathematics anxiety levels between high school students (grades 9 to 12) in Jordan (n = 684) and their counterparts in the United States (n = 604). She also investigated whether ethnic background relates to mathematics anxiety among high school students in the United States. Muqdadi's findings showed that students in Jordan had significantly higher levels of mathematics anxiety than those in the United States, $t(1286) = 5.22$, $p < .000$, indicating that the result could be partly related to differences in students' educational experiences and culture. In the different racial groups (White, Black, Hispanic, Asian, and Others) only White American high school students had significantly lower mathematics anxiety level than the African American high school students (mean difference of 20.28). There was no significant difference for all other combinations of different racial groups that were tested through the post hoc procedure.

Another study conducted in the United Kingdom by Fuson (2007) investigated mathematics anxiety and its relationship with age, gender, and ethnicity. The participants were 57 adult students (27 female; 30 male) who were enrolled in mathematics courses at three universities situated at two American military installations. Their ages ranged from 18-49 years and they were made up of six ethnic groups, namely: African American (9), American Indian or Alaskan Native (1), Asian or Pacific Islander (2), Caucasian (35), Hispanic (4), and Others(4). The study used *Attitudes Toward Mathematics Inventory* (ATMI) instrument (developed by Tapia and Marsh, 2004) together with a demographic survey. Fuson (2007) conducted independent t-tests on self-confidence, value, enjoyment, and motivation by ethnicity (Caucasians vs. minorities) and found no significant differences for self-confidence, $t(53) = 1.29$; $p = .20$; value, $t(53) = .85$; $p = .40$; enjoyment, $t(53) = 1.57$; $p = .12$; and motivation, $t(53) = 1.96$; $p = .06$. The finding showed that mathematics anxiety could not be predicted by the ethnicity of the participants in the study. One of the limitations of the study was that some of the participants had not enrolled in a mathematics course for a long time and could therefore not precisely recall the experience of mathematics anxiety that they encountered many years ago when solving mathematics problems in mathematics classes. Recruiting participants, such as in-service elementary school teachers, who deal with mathematics on a daily basis, gives a possibility of having respondents that are more likely to recall precisely their experiences with mathematics anxiety.

It should be noted that none of the research stated above was conducted with elementary school teachers. Through better understanding of characteristics of teachers who experience mathematics anxiety, intervention programs and manuals can be created to help them diminish or perhaps overcome their anxieties over the subject. Research on how factors such as ethnicity, socioeconomic status, and race relate to mathematics anxiety warrant further research. Thus, one of the purposes of this study was to examine mathematics anxiety and its association with selected demographic characteristics among in-service elementary teachers with diverse ethnicities and races.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

The previous chapter provided a literature review on mathematics anxiety and reasons why more research is needed in this area, particularly with in-service elementary school teachers. This chapter describes the methodology for the study, provides an overview of the research, details of research design and the sample, methods of data collection and analysis, and ethics considerations for the study.

Research Questions

This study addresses the following four research questions:

1) What are the levels of mathematics anxiety among in-service elementary school teachers and how do their anxieties differ in view of varied socio-cultural factors?
2) What are the types of mathematics teaching anxiety experienced by in-service elementary school teachers?
3) What is the relationship between in-service elementary school teachers' mathematics anxiety and mathematics teaching anxiety?
4) What are the self-reported causes of mathematics anxiety among elementary school teachers and what strategies did they use to cope with, diminish, or overcome it?

Research Design - Justification for the Sequential Explanatory Mixed Method Design

The mixed methods approach was used to answer the study research questions. Johnson and Onwuegbuzie (2004) describe mixed methods research as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts, or language into a single study" (p. 17). Mixed methods is also defined as a procedure that utilizes both quantitative and qualitative methods for collecting and analysing data, integrating the findings, and drawing inferences in a single study (Tashakkori & Creswell, 2007). The rationale for combining two types of data is that quantitative or qualitative research, each by itself, is insufficient to understand the trends and details of situations (Creswell, 2012; Ivankova & Stick, 2007), such as teachers experiencing mathematics anxiety while teaching. The mixed methods design counterbalances the weaknesses of both quantitative and qualitative research, and provides for additional evidence for examining a research problem (Creswell & Plano Clark, 2011). Besides, this method is appropriate for this study as it allows the generalization of findings to a larger group, as well as ensuring that participants' (i.e., teachers') voices are heard.

Specifically, this study employed a sequential explanatory mixed methods design that consists of two distinct phases (Tashakkori & Teddlie, 1998) in which the researcher "collect[ed] quantitative data and look[ed] for extreme cases to follow up in a qualitative phase" (Creswell, 2005, p. 521). That is, the quantitative data were gathered through surveys and analyzed in the first phase, to provide a general picture of the research problem and help in selecting participants for the second phase, while the qualitative data were collected through interviews in the second phase, to help explain or elaborate on the quantitative results that were obtained in the first phase. Also, the data collected through interviews allowed participants to discuss and give details on their past and current feelings and experiences of mathematics anxiety. The integration of the two phases was done during the interpretation of findings from the study. The diagram below (see Figure 1) illustrates the two phases and their points of mixing.

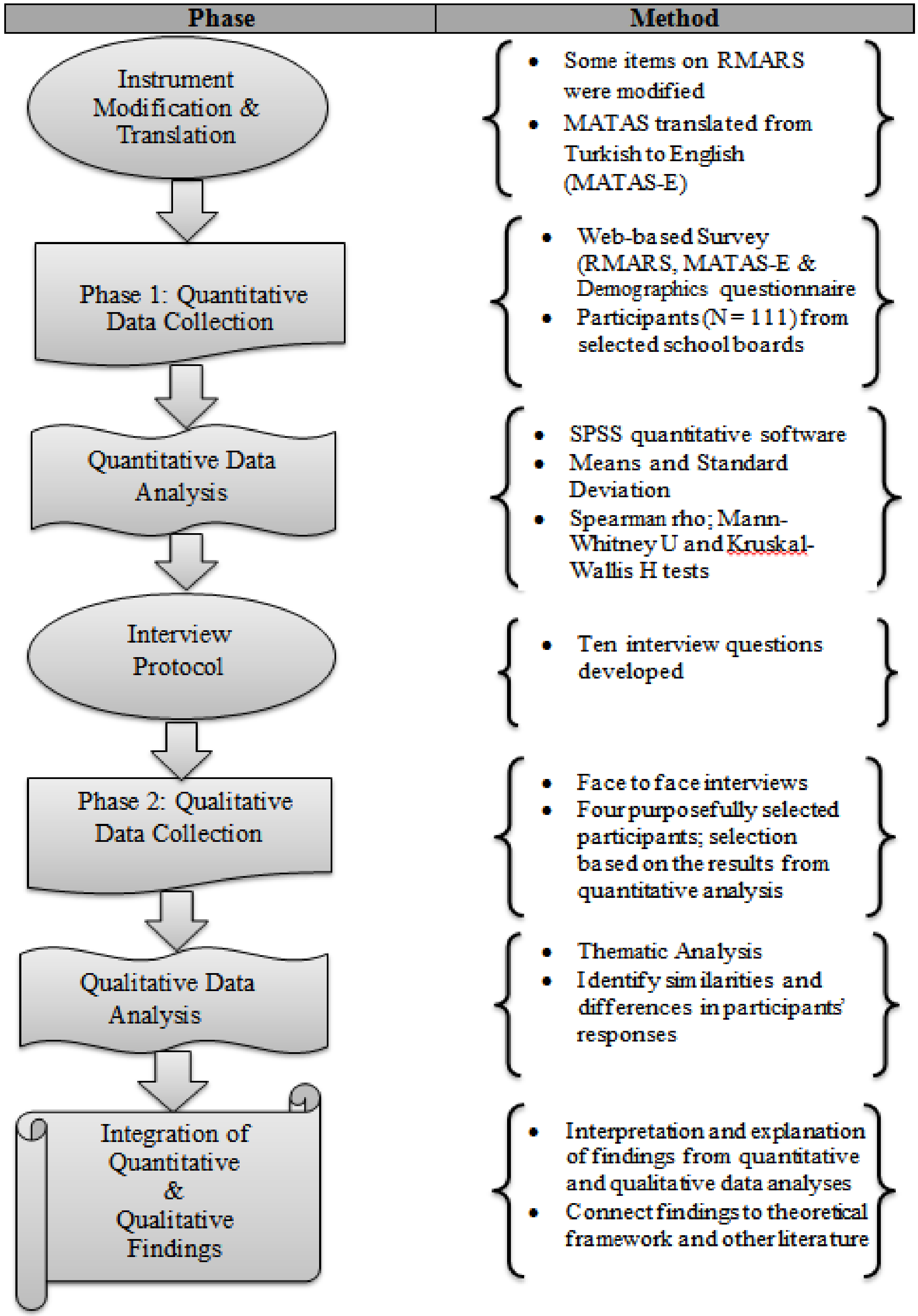

Figure 1. Sequential explanatory mixed methods design adapted from Ivankova and Stick (2007)

Sampling

The targeted population in this study were in-service elementary school teachers from Grades 1 to 8 classes. The convenience sampling (Cohen, Manion, & Morrison, 2000; Nardi, 2006) was used to select school boards in Southern Ontario for the research. Two school boards, with an estimated population of 750 elementary in-service teachers, positively answered to the researcher's invitation to participate in the study. After obtaining approvals from the University Windsor Research Ethics Board and the Superintendents of the two Boards of Education, elementary school teachers from the boards were invited to participate in an online survey through the boards' mailing lists. In the first, quantitative, phase, a total number of 163 elementary in-service teachers responded to the online survey, out of which 15 of them did not complete more than half of the items on the survey and were excluded from the study. Also, data from respondents who were special education teachers (33) and school principals (4) were not analysed. Only data collected from the remaining 111 in-service elementary school teachers were analysed and reported in the quantitative part of the study. The expected response rate is generally low for online surveys (around 10%, or 50 per 500 potential participants, Kraut et al., 2004), but cost and convenience outweigh this known disadvantage (Reips, 2002). The response rate was approximately 15%, indicating a low response rate for the first phase.

In the second (qualitative) phase of the study, the response rate was also low as only four in-service elementary teachers volunteered to take part in the interview. The limitations of the study regarding the low number of participants are discussed in Chapter Five.

Data Collection: Quantitative Phase

In the quantitative phase of data collection, the researcher developed a questionnaire (see Appendix A) that contained questions relevant to various demographic and socio-cultural factors (e.g., ethnicity, socializers) and other variables that could be associated with mathematics anxiety. These factors include gender, race, parent's educational background, socioeconomic status, number of years of teaching, and highest level of mathematics studied in school. In addition to using the demographic questionnaire, *the Revised Mathematics Anxiety Rating Scale (RMARS)* (see Appendix B) was used as the quantitative instrument to examine the level of mathematics anxiety in elementary teachers (i.e., low, moderate, high), whilst the *Mathematics Teaching Anxiety Survey* (*MATAS*) was used to determine the types of mathematics teaching anxiety they experienced (e.g., anxiety due to subject knowledge, self-confidence, attitude towards mathematics, and teaching knowledge.; Peker, 2006). Permissions to use RMARS and MATAS for this study were obtained from the authors of the instruments.

Instrumentation. The RMARS was developed from the first instrument, *Mathematics Anxiety Rating Scale* (*MARS*), devised by Richardson and Suinn (1972) to measure mathematics anxiety. MARS is a multidimensional instrument that measures two distinct aspects—numerical anxiety and mathematics test anxiety—as well as other aspects, such as mathematics course anxiety (Rounds & Hendel, 1980; Satake & Amato, 1995). MARS is one of the most frequently used surveys to measure mathematics anxiety, perhaps due to a large pool of its psychometric properties that are addressed in the literature. However, its length (98 items) remains a concern as it can be time-consuming for participants to complete, and for researchers to administer and score (Alexander & Martray, 1989; Ashcraft & Moore, 2009; Dunkle, 2010). Alexander and Martray (1989) examined the psychometric properties of MARS and developed its abbreviated version (namely RMARS) as a quick and effective measure of mathematics anxiety. The researchers made RMARS available in their publication for other researchers to use at no cost. The RMARS is a 25-item survey comprising of three subscales—the mathematics test anxiety subscale (15 items), which measures individual's reactions to evaluative situations in mathematics; the mathematics course anxiety subscale (5 items), which measures individual's reactions to being in a mathematics class; and the numerical anxiety subscale (5 items), which assesses anxiety resulting from basic mathematics activities such as multiplication and division (Baloglu & Zelhart, 2007; Kazelskis, 1998). The Cronbach alpha coefficients (internal consistency reliability measures) of mathematics test anxiety, numerical task anxiety, and mathematics course anxiety were reported to be .96, .86, and .84 respectively, demonstrating the sound reliability of the instrument. The RMARS total scores correlate with the 68-item MARS at .93. The 68-item MARS, obtained through principal factor analysis, had an internal consistency coefficient of .97 (Alexander & Martray, 1989). In addition, Balogˇlu and Koçak (2006) used RMARS with 759 college students and reported the internal consistency reliability as .95 for the total scale, with the Cronbach alpha for the subscales as .95, .87, and .88 numerical task anxiety, .87 mathematics test anxiety, and mathematics course anxiety respectively. The reported results indicated substantial support for RMARS as a representative of MARS. The items on RMARS, like its predecessor MARS, are designed using a 5-point scale where the responses are 1 (*not at all*), 2 (*a little*), 3 (*a fair amount*), 4 (*much*), and 5 (*very much*). The total score for an individual can vary from 25 to 125 with higher score corresponding to higher mathematics anxiety level.

The initial construct validity of RMARS was found from a sample of 517 undergraduate students (Alexander & Martray, 1989) and its initial concurrent validity was tested in comparison with the Fennema-Sherman Attitude Scale (1976). This comparison produced a negative correlation that indicated that individuals with more positive attitudes toward mathematics experienced less mathematics anxiety (Alexander & Martray, 1989). Since the RMARS has not been used with teachers as participants, in this present study, two of its items (# 3 and # 4) were modified to better fit teachers (rather than students). For example, item #4, in its original form, was “listening to another student explain a math formula” and was replaced with “listening to another student (or teacher) explain a math formula.” The rationale for using the RMARS is that it is a highly reliable instrument that assumes the multidimensionality of mathematics anxiety. That is, it measures individuals’ reactions to taking mathematics test (mathematics test anxiety), being in a mathematics class (mathematics course anxiety), and doing basic mathematics activities (numerical task anxiety).

On the other hand, MATAS is a 5-level Likert scale Turkish instrument that was developed by Peker (2006). It consists of 23 items with 5 responses to each item—1 (*I absolutely agree*), 2 (*I agree*), 3 (*I am undecided*), 4 (*I don’t agree*), and 5 (*I absolutely don’t agree*). Positive responses (13 items) were coded from 1 to 5 while the negative ones (10 items) were reverse-coded from 5 to 1. MATAS is a four factor scale that measures teaching anxiety due to subject knowledge (10 items), anxiety due to self-confidence (6 items), anxiety due to attitude towards teaching mathematics (4 items) and anxiety due to subject teaching knowledge (3 items). The reliability coefficients (Cronbach Alpha) of the four factors are reported to be .90, .83, .71, and .61 respectively while the entire scale has a .91 reliability coefficient. To establish the validity, Peker (2006) carried out exploratory factor analysis and reported the analysis of variance for the four factors to be 35.37%, 8.55%, 6.57%, and 5.97% respectively. Peker (2006, 2009) and some other scholars (e.g., Yazıcı & Ertekin, 2010) used MATAS with pre-service teachers as participants. To date, there appears to be no history of MATAS being used to determine elementary in-service teachers’ mathematics teaching anxiety in the literature. Therefore, this study not only adds to the body of knowledge on mathematics anxiety, but also to the body of knowledge on mathematics teaching anxiety among in-service elementary school teachers.

MATAS translation. MATAS was originally created in Turkish language by Peker (2006). The instrument was translated into English language for the purpose of this study. The researcher obtained approval from Dr. Peker to use the translated version of the instrument. Many researchers (Hilton & Skrutkowski, 2002; Weeks, Swerissen, & Belfrage, 2007) describe a variety of approaches that are used in instrument translation. However, there is no common agreement among them on how the approaches should be employed or amalgamated (Maneesriwongul & Dixon, 2004). These approaches include forward translation (or one-way translation), back translation, committee approach, and pre-test procedure, which could be used to translate an instrument from source language to target language. In this study, the forward translation was used to translate MATAS from the source language (Turkish) to the target language (English). Weeks et al (2007) stated that a forward translation method is one of the key translation approaches that involve a bilingual individual translating the original version of an instrument into a target language. However, they emphasised that a combination of translation approaches, with room for adaptability and readiness to change, is needed to make sure that the instrument is successfully translated. In a similar manner, Maneesriwongul and Dixon (2004) suggested that "all studies involving instrument translation should include information to establish that translation processes were adequate" (p. 181). In line with the researchers' suggestions, the following steps describe the translation process used for MATAS in this study:

i) Two independent translators, a professor in mathematics education and a post-doctoral student in engineering, who are bilingual, with the source language (Turkish) as their first language, were contacted at different times to assist in the translations.

The translators were familiar with and had experience in mathematics-related work and research. They were chosen to avoid mistakes in the translation of mathematics-related terminologies that may surface in the instrument.

ii) Their translations were compared to detect discrepancies in words, meanings, and sentences. Some discrepancies were addressed and corrected as the researcher had extensive discussions with the post-doctoral student to gain better understanding of the reasons why such discrepancies existed. For example, while one translator used “I love to reply to questions regarding the mathematics topic I am teaching” and “I believe that it is really hard for me to teach mathematics concepts” in the translation of some items on the MATAS instrument, the other translator used “I like to reply to questions regarding the mathematics topic I am teaching...” and “I think that it is really hard for me to teach mathematics concepts”. Emphasis was placed on the meaning of each item on the instrument rather than verbatim translation.

iii) After the initial translation, the English version of MATAS was pilot-tested among 10 individuals that included a librarian, graduate students, teachers, and educators for clarity of items and for the comprehension of the translated instrument. Participants were asked to note words and expressions that they could not comprehend or that they had problems with. In addition, they were asked to select the option, “love” or “like” and “believe” or “think” that corresponds well to their everyday language use. Generally, the participants picked “like” and “think,” as opposed to “love” and “believe,” and the English version of the MATAS instrument was adjusted appropriately. The translated MATAS instrument is referred to as MATAS-E in this study (see Appendix C).

In the first phase of data collection, the survey instruments were administered online and accessed by teachers through the in-service teachers' active email addresses. An online survey was created with Fluid Survey software and kept at the University of Windsor secured server. The address to the server was sent to the school boards for onward distribution to their teachers using their mailing list. The invitation by the Boards to the teachers contained the invitation letter, access to the link that provided the three survey instruments, and information about the researcher for those who wanted to participate in the interview or needed access to the hard copy of the survey. No hard copy of the survey instruments was mailed or sent as a Word document attachment to teachers as none of them requested for it. The first page of the online survey contained the consent to participate in research (Appendix E) which teachers were asked to read before beginning the survey. The page provided information about the purpose of the study, procedures, potential risks and benefits, confidentiality, participation and withdrawal rights, and ways to obtain results of the study. Completion of the survey required about 18-20 minutes and participants were asked to authorise their participation by clicking the "Submit" button on the last page of the survey. In addition, participants had the option of providing their personal contact information (e.g., name and e-mail) when completing the surveys to identify potential participants for the one-to-one interviews. Due to very low initial response to the survey, the researcher visited various schools to talk to the principals to seek teachers' participation in the study and appealed that they encourage their staff (in-service elementary teachers), within and outside their schools, to volunteer as participants. As a result, a second call for teachers' participation was forwarded to the teachers, through their principals, as a reminder for those who may be interested in completing the survey but had not done so.

Data collection for this quantitative phase started during the summer of 2014 and continued through the winter 2015 semester. Data collection was interrupted from June 26, 2014 to September 1, 2014 as the academic school year ended and teachers were on summer break and did not respond to the survey.

Data Collection: Qualitative Phase

In the second phase, semi-structured interviews were conducted with four purposefully selected teachers who volunteered to participate in the interviews. Initially, since the focus of this study is mainly on mathematics anxiety, the researcher intended to select two males and two females who showed a high level of mathematics anxiety (HMA) and a high – to – low level of mathematics teaching anxiety (HMTA, MMTA, or LMTA) in the survey and two males and two females, who have experienced mathematics anxiety but feel they have reduced or overcome it. However, none of the male participants' scores on RMARS fell under the category of high mathematics anxiety level as their scores fell in the low and moderate mathematics anxiety levels. All the male participants (seven out of 20) who provided their email addresses on the online survey were invited through email to participate in the interview. In a similar manner, female participants (22 out of 87) whose scores fell in the high end of moderate level (that is, scored above 60), together with those with high level of mathematics anxiety, were also contacted to partake in interviews. The invitation to participate was sent out twice (over the span of two months) after which the researcher received an e-mail notification from one male participant (with low mathematics anxiety score) and three females (with one moderate and two high mathematics anxiety scores) that were interested in participating in the interviews. All four respondents were from different schools and they were interviewed at their preferred locations.

An interview protocol (see Appendix D) that contained 10 open-ended questions was developed by the researcher to elicit from the participants elaboration on the results from the quantitative part and also to explore the causes of mathematics anxiety among participants and how they overcame or coped with their anxieties. The interview protocol was designed to ensure the collection of comparable data among the participants. Besides, interviews designed with open-ended questions do not compel participants to tailor their experiences and knowledge into the researchers' classification, rather, they "allow respondents to express their understanding in their own terms" (Patton, 2002, p. 348). Since the main focus of this study is on mathematics anxiety, most of the open-ended questions probe for socio-cultural influences and past experiences that could have led to mathematics anxiety experienced by these teachers. However, one question (item # 4) related to mathematics teaching anxiety was included in the interview protocol. This question probes further for clarifications on the development and causes of mathematics teaching anxiety among the participants. Rubin and Rubin (2005) asserted that many important questions could be answered through surveying and experimenting, but "statistical summaries may not communicate, because numbers do not tell a story that people easily understand" (p. 2). Thus, interviews were used to gain insights beyond what was provided through the survey instruments. The benefit of using the interview method of data collection in the study was that it allowed in-service teachers to further elaborate on their past and current experiences, which in turn provided the researcher with a richer description of their perspectives on mathematics anxiety as well as mathematics teaching anxiety. Interviews with selected participants began immediately after the quantitative data were analysed. The interviews took about 45 minutes for each participant to complete and were recorded on a digital recorder. Each of the selected participants was asked to read and sign the letter for Consent for Audio Taping of the interview (see Appendix F) before commencing the interview. In total, the interviews took about four weeks to conduct.

Data Analysis: Quantitative Phase

In the first phase, data collected through the online survey were inputted into SPSS software, Windows version 16.0. Scores for each participant were computed by adding the item values on the RMARS and MATAS-E. The negative items (10) on MATAS-E were reverse-coded before the total scores for participants were calculated. These data were analysed using the methods of descriptive and inferential statistics, such as means, standard deviations, Mann-Whitney U test, and Kruskal-Wallis test, to address Research Questions 1 and 2. Participants' scores on RMARS and the overall means and standard deviations of their scores were used to assign them into anxiety groups (i.e., low, moderate, high). That is, participants whose scores on RMARS were at least one standard deviation below the overall mean were categorised as possessing low mathematics anxiety level, while those with scores that were at least one standard deviation above the overall mean were considered as having high mathematics anxiety level. Moderate mathematics anxiety level was assigned to participants whose scores were not up to one standard deviation below or above the overall mean.

Huck (2004) stated that, if the assumptions of normality and homogeneity of variance are violated, non-parametric tests could be more powerful than their parametric counterparts and "provide researchers with greater protection against Type II errors" (p. 509). In this study, nonparametric techniques were used for data analysis since the data collected with RMARS and MATAS-E were skewed and the variances for the groups (e.g., females and males) that were compared could not be assumed equal. The Mann- Whitney U and Kruskal-Wallis tests were performed on the mathematics anxiety scores obtained from RMARS to determine whether there were statistically significant differences among the groups of participants with respect to gender, socioeconomic status, parental educational levels, number of years of teaching, and highest mathematics course taken.

The Spearman's Rank-Order correlation (r_s) of the participants' RMARS and MATAS-E scores was calculated to examine the relationship between mathematics anxiety and mathematics teaching anxiety (thus, addressing Research Question 3). Tables and figures were used to present the results from the quantitative phase and the initial analysis of data gathered through the online survey was completed in 6 weeks.

Data Analysis: Qualitative Phase

In the second phase of the study, the researcher transcribed the interviews recorded with each participant. The transcripts were analyzed using thematic analysis, which has been used by other researchers (Boyatzis, 1998; Ezzy, 2002) from many fields. Braun and Clarke (2006) described thematic analysis as one that "provides a flexible and useful research tool, which can potentially provide a rich and detailed, yet complex, account of data" (p. 78). Due to its flexibility, thematic analysis allows a researcher to determine themes in many ways as the researcher is cognisant of consistency in the way the data are being analyzed. The method of thematic analysis entails continually going back and forward between a) the entire set of data, b) the coded extracts of data that are being analysed, and c) the analysis of the data that are being produced (Braun & Clarke, 2006).

The thematic analysis that was employed in this study followed the six phases outlined by Braun and Clarke (2006) to analyse the data collected from interviews with selected in-service elementary teachers. These phases include: i) reading through the transcribed data continuously and taking notes of the initial ideas in the data; ii) producing initial codes by coding interesting aspects of data from each of the participants' responses to a particular question, as well as the entire data, and matching the codes with data extracts that illustrate that code; iii) identifying themes by sorting various codes into themes and collating data extracts for each theme; iv) reviewing the themes to ensure that themes are harmonious with the coded extracts and the entire data set; v) assigning definitions and names to each theme as a way of determining the aspects of the data captured by various themes and vi) providing clear, non-repetitive, logical, and sufficient evidence of the themes during the write up of the report.

In accordance with Braun and Clarke's (2006) step-by step guide for thematic analysis, the researcher read through the interview transcripts to familiarise herself with the data and noted the initial ideas in participants' responses. Thereafter, preliminary codes were produced based on the research questions. For example, codes such as "fast-paced instruction", "review on mathematics concepts", "lack of understanding", "derogatory comments", "self-confidence", "tutoring" "mathematics avoidance", "motivation", "personal struggles", and "peer pressure" were assigned to participants' responses and the data extracts supporting the codes were noted (see Appendix H for the list of codes that were identified across the data). These codes were then sorted into themes with their corresponding data extracts merged under each theme. At the same time, some of the codes that did not fit into the main themes were discarded. The codes that were excluded were more related to participants' struggles to complete university degree (e.g., "I am the only one in my family who is a graduate, so I was kind of on my own as far that was concern. When I went to the university that was on me… I worked so I can go to the university") and participants informing parents of their students about school activities (e.g. "I upload very short video for parents to watch and showing them different [teaching] strategies").

After identifying the themes, subsequent review and refinement of the themes were done by reading all the assembled extracts for each theme to ensure that they form a coherent pattern. Also, the researcher checked whether similar themes appeared anywhere in the participants' responses and in other responses in the entire data set. Data extracts that had been put together to support themes were crossed out and the remaining data were re-examined to generate more themes. This process continued until no more themes were identified. Themes within the data were identified using a theoretical or deductive approach (Boyatzis, 1998) where the data were coded for a specific research question, concerning the causes and influences of socio-cultural factors on mathematics anxiety as reported by the participants, to provide more detailed analysis of some feature of the data (Braun & Clarke, 2006). The emerging themes from the analysis are presented and discussed in Chapter Five.

Employing the method of thematic analysis allowed the researcher to capture the key aspects of the influences socio-cultural factors may have on the participants' mathematics anxiety and how the participants coped with, reduced, or overcame their mathematics anxiety. Since the aim of this study was to describe participants' perceptions of their anxieties over mathematics, identification of themes was done at a semantic level. That is, themes were identified only by considering the surface meanings of participants' responses to the interview questions rather than looking beyond what they said. As explained above, emerging themes and patterns in the participants' responses were noted. Any features related to other socio-cultural factors among participants were presented in tabular form for easier comparison. Responses from one elementary male teacher and three female teachers were examined for clarifications and understanding of their perceptions on causes of and experiences with mathematics anxiety; thus addressing Research Question 4, which was analyzed qualitatively.

Reliability and validity. According to Creswell and Clark (2011), reliability implies that "scores received from participants are consistent and stable over time" (p. 211) when the instrument is repeatedly administered. The Cronbach alpha coefficient of a scale that is greater than .70 is regarded as a good indicator that the scale is reliable (Fraenkel &Wallen, 2006; Nardi, 2006; Pallant, 2005). As previously explained, the internal consistency reliability coefficients (Cronbach alpha) of RMARS subscales were reported as .96 for mathematics test anxiety, .86 for numerical task anxiety, and .84 for mathematics course anxiety while the entire scale correlated with the 68-item MARS at .93 (Alexander & Martray, 1989). Two week test-retest reliability of RMARS obtained from a sample of 62 undergraduate students was reported as .86 (Alexander & Martray, 1989). High reliability coefficient (.95) was also reported by Balogˇlu and Koçak (2006) for the total RMARS. In this current study, the reliability coefficient of RMARS scale was found to be reliable at .97. In addition, the Cronbach alpha for the entire MATAS (English version) scale was calculated as .96, indicating a high internal consistency which compares favourably with the .91 reliability coefficient reported by Peker (2006) for the original MATAS Turkish instrument. The Cronbach Alpha of the four subscales of MATAS-E (mathematics teaching anxiety due to subject knowledge, self-confidence, attitude towards mathematics, and general teaching) were .93, .94, .94, and .88 respectively. Therefore, the RMARS and MATAS-E instruments are considered as reliable measures.

Two procedures, construct and concurrent validity, were used to validate the RMARS instrument. The validity of the translated MATAS was established through content validity. Expert judges, including a university professor in mathematics education and a librarian, evaluated whether the items represent the construct they were supposed to capture. In addition, the credibility of the qualitative research findings was validated through an external auditor (that is, an educator with PhD degree from another institution) who reviewed the qualitative data and the results from the data using her criteria (Creswell & Clark, 2011). These criteria were: i) the extent to which the results emerged from the data collected rather than the researcher's pre-conceived ideas, and ii) the frequency of direct quotations and representation of participants' voices. According to Teddlie and Tashakkori (2009), data triangulation has been extensively recommended as a "strategy for assessing the overall quality of data, especially in mixed research" (p. 213) In this sense, the data triangulation techniques included in this mixed methods design with both quantitative data (surveys) and qualitative data (interviews) collected and analysed and their results integrated to comprehend more fully the experiences of mathematics anxiety among in-service elementary teachers, provided more accuracy to the study.

Ethics Considerations

The study followed all ethics procedures and guidelines for graduate student research. Approval was obtained from the University of Windsor Research Ethics Board (see Appendix G) after which clearance was received from the superintendents of the school boards that took part in the study. All participants were informed that their participation was voluntary; that they may withdraw at any time without penalty; and that they may choose not to answer any question. Completion of the survey was taken as consent to take part in the study. The data collected were encrypted and the password to access the data was kept by the researcher, thus ensuring confidentiality.

For the interviews, participants' identities were kept confidential. Their true names were replaced by pseudonyms so as to protect their identities and any information, such as location of school, from which their identities could be inferred, was not reported. All information provided by participants was securely stored in a locked cabinet in the researcher's supervisor's office for a period of two years after which it will be destroyed.

This chapter has provided a detailed description of the methodology used for the study. It includes the description of data collection and analysis, information about instruments' reliability and validity, and the ethical considerations for the study. The next chapter presents summaries of quantitative and qualitative data analyses. The discussion on the emerging themes that were identified from the qualitative data is also included.

CHAPTER FOUR

RESULTS

The purpose of this study was to explore the nature and causes of mathematics anxiety, and its relationship with mathematics teaching anxiety and demographics factors such as, gender, race/ethnicity, socioeconomic status, and parental educational level. The study also examined the causes of mathematics anxiety and the ways elementary school teachers cope with, diminish, or eliminate their anxiety about mathematics. This chapter presents the data analyses and findings from two phases of the study. Descriptive statistics, such as means and standard deviations, were used to categorize, summarize, and visually present results based on the quantitative data, while inferential statistics, such as Mann-Whitney U and Kruskal- Wallis, were used to determine the relationship between the participants' mathematics anxiety and mathematics teaching anxiety; as well as to establish whether there are statistically significant differences between sample groups (e.g., males, females). The dependent variables for the study were the teachers' scores on the Mathematics Anxiety Rating Scale-Revised (RMARS) and the Mathematics Teaching Anxiety Scale (MATAS-English version referred to as MATAS-E). The independent variables were - gender (male and female), socioeconomic status, race/ethnicity, highest level of mathematics studied, and parental educational level. Some of the data analyses are summarized and displayed in tabular forms.

Phase 1(Quantitative Part): Results from Online Survey

The online survey that was completed by participants had three main parts: (i) a questionnaire that contained 13 questions about demographic factors that could be associated with mathematics anxiety and teachers' past experiences with mathematics anxiety; (ii) RMARS that consisted of 25 questions about real life and academic situations that could generate mathematics anxiety and; iii) MATAS (English version) that contained 23 questions about mathematics teaching anxiety.

Participants. The participants in the study were 111 in-service elementary school teachers. Eighty seven 87 (78.4%) of them were females, 20 (18%) were males, and 4 (3.6%) of them did not respond to the survey's gender question. As presented in Table 1, the analyses of demographic information showed that the participants were mostly White (94: 85.5%) and none of them self-identified as Hispanic or Latino and Aboriginal (First Nations, Metis, Inuit, Native American). However, four participants (3.6%) self-identified as "Other," which in the survey represented participants that belong or identify themselves as belonging to multiple ethnicities. Three out of four of them did not specify their multiple races or ethnicities and one of them identified as White, Black, and Aboriginal. Five participants self-identified as Middle Eastern, three as Asian, and four as Black or African American/Canadian. One participant did not respond to the race/ethnicity question. In addition, over two-thirds of the participants (87.4%) perceived themselves to belong to middle socioeconomic status (SES) family during their elementary school years. Participants' responses to the question "What is the highest level of mathematics you have studied in school?" indicated that of the 110, with one participant's response missing, approximately 61% had studied mathematics as far as grade 12, while 39% had studied the subject at the post-secondary level. At the time of the study, participants were teaching in grades 1 to 8.

Table 1

Descriptive Statistics for Participants' Demographic Information

Demographic Variable	*n*	%
Gender		
Male	20	18.0
Female	87	78.4
Unspecified	4	3.6
Race/Ethnicity		
White	94	86.9
Black or African American/Canadian	4	4.7
Asian/Pacific Islander	3	1.9
Middle Eastern	5	4.7
Aboriginal	0	
Hispanic or Latino	0	
Other	4	1.9
Socioeconomic Status (SES)		
Low SES	12	10.8
Middle SES	97	87.4
High SES	2	1.8
Highest Level of Mathematics Studied		
Grade 10	5	4.5
Grade 11	11	10.0
Grade 12	51	46.4
College	2	1.8
University	41	37.3

Research Question 1

This question investigated the levels of mathematics anxiety among in-service elementary school teachers and how their anxieties differ in view of varied socio-cultural factors. In order to find levels of mathematics anxiety that participants experienced, the RMARS composite scores were calculated by adding their responses to each item on the survey. Table 2 displays the descriptive statistics of RMARS scores for 111 in-service elementary teacher participants. The lowest score obtained was 25 and the highest was 114 out of the possible 125. There was a big difference among the values of mean, median, and mode for the whole sample. The mean (M = 52.88) of the RMARS scores was greater than median (Mdn = 48) and the mode, with the modal score (Mo = 25) being the lowest. Therefore, the best measure of central tendency was the median. A positively skewed distribution was noted with a skewness value of .77. A negative kurtosis value of -.22 indicated that the distribution was relatively platykurtic. Figure 1 presents the distribution of participants' mathematics anxiety scores, as measured by RMARS.

In addition, the assessment of the normality of the distribution of mathematics anxiety scores for male and female participants was done using SPSS software. A Shapiro-Wilk test (p <.05) suggested that the scores violated the assumption of normality.

Table 2

Descriptive Statistics of RMARS Scores (N = 111)

Descriptive Measure	Value
Mean	52.88
Std. Error of Mean	2.12
Median	48.00
Mode	25.00
Std. Deviation	22.3
Skewness	.77
Std. Error of Skewness	.23
Kurtosis	-.22
Std. Error of Kurtosis	.46
Minimum	25
Maximum	114

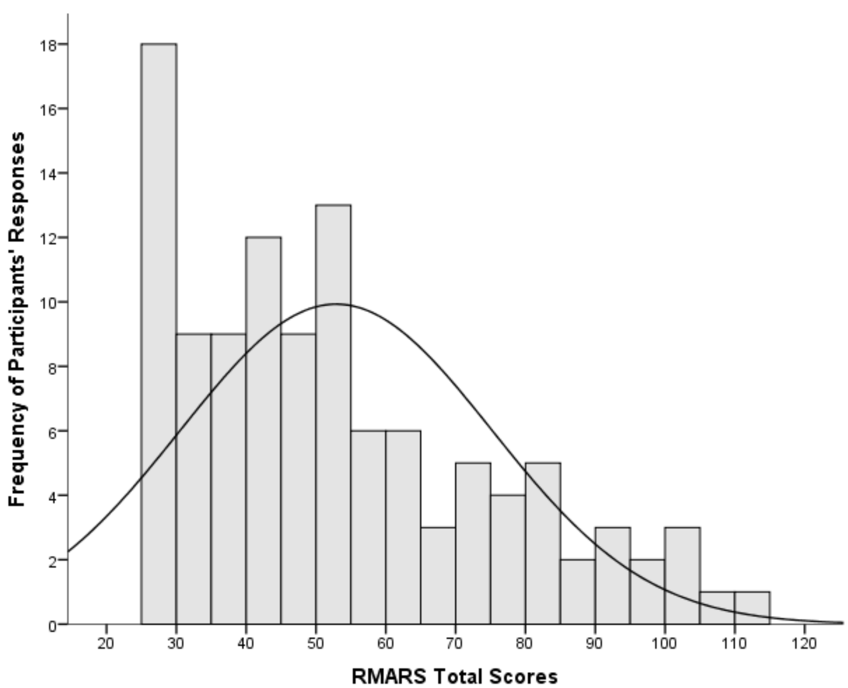

Figure 2. The distribution of participants' mathematics anxiety scores as measured by RMARS

Participants' were categorised into three mathematics anxiety levels following the grouping method used by Ashcraft and Kirk (2001), where RMARS instrument was utilized to measure the levels of mathematics anxiety in undergraduate students. Thus, participants in this study were categorised by calculating the cut off scores based on the overall sample mean and standard deviation of the RMARS scores. In the first category were participants whose RMARS scores were at least one standard deviation below the overall mean and they were considered as having low mathematics anxiety. In the second category are those whose RMARS scores were at most one standard deviation below and above the overall mean and they were categorised as having moderate mathematics anxiety. In the third category were those with scores that were at least one standard deviation above the overall mean and they were considered as having high mathematics anxiety (see Table 3). The results indicated that 19 (17.1%) of the 111 participants experienced low level of mathematics anxiety, 71 (64%) experienced moderate level, and 21 (18.9%) experienced high level of mathematics anxiety.

Table 3

Results on Levels of Mathematics Anxiety Experienced by Participants

MA Level	*n*	RMARS range	*M*	*SD*
Low	19	25-30	26.58	1.68
Moderate	71	31 -75	48.75	11.49
High	21	76-114	90.00	10.81
Total	111	25-114	52.76	22.34

Note. MA = mathematics anxiety. Low scores on R-MARS scale are indicative of low mathematics anxiety.

On the other hand, results from the demographic question (item #9) revealed that, of 111 participants, 71 (64%) of them perceived their current mathematics anxiety levels as low, 34 (30.6%) as moderate, and 6 (5.4%) as high. Comparing their perceived levels of mathematics anxiety with their scores on the RMARS scale, it was found that participants who indicated low mathematics anxiety level scored between 25 to 94; moderate mathematics anxiety level scored between 25 to 114; and those with high mathematics anxiety level scored between 47 to 105. These results indicated that some of the participants who perceived their mathematics anxiety levels as low and moderate seemed to have a high level of mathematics anxiety as their scores were not too far from the highest possible score of 125 on the RMARS scale. Specifically, one of the participants in the moderate mathematics anxiety level had the highest score on the RMARS scale in this study.

The second part of the first research question was addressed by examining participants' mathematics anxiety scores in relation to their gender, race/ethnicity, socioeconomic status (SES), highest level of mathematics studied, and parental educational level. The analyses that were conducted as well as their results are presented in the following text.

Mathematics anxiety and gender. Data from 107 in-service elementary school teachers were used for this analysis. The males' mathematics anxiety mean score (M = 37.6, SD = 10.8, n = 20) was lower than the females' mean score (M = 56.67, SD = 22.67, n = 87). A non-parametric test, the Mann-Whitney U, was carried out to compare the mathematics anxiety scores between the two groups. A statistically significant difference, U = 415.5, Z = -3.63, p < .001, was found in mathematics anxiety scores between the male participants (Mean rank = 31.28) and female participants (Mean rank = 59.22). A further look at the mean ranks for the two groups suggested that mathematics anxiety was greater in female participants than in males. The effect size (r), calculated by dividing the Z value by the square root of N (107), was found to be moderate at .35 following the guidelines proposed by Cohen (1988, 1992). In this current study, the interpretation of the effect sizes that were calculated used Cohen's guidelines: that is, .10 = small effect, .30 = moderate effect, .50 = large effect.

Mathematics anxiety and race/ethnicity. Since the majority of the participants were White and the other racial/ethnicity categories had small number of respondents, the participants were divided into two groups (White, n = 94 and Non-White, n = 12) to obtain a realistic picture of the test. The mean score for White group was 51.53 with a standard deviation of 21.89 while the Non-White group had a mean of 51.33 with a standard deviation of 20.87. When the mean values were compared, Non-White group and White group had very close mathematics anxiety mean score, with a difference of .2. The Mann Whitney U result showed no statistically significant difference (U = 554.5, Z = -.095, p = .925) in mathematics anxiety scores between White group (mean rank = 53.40) and Non-White (mean rank = 54.29).

Mathematics anxiety, socioeconomic status (SES), and parental educational level. As previously shown in Table 1, the majority of the participants perceived their families to belong to middle SES during their elementary school years (low SES: n = 12, middle SES: n = 97, high SES: n = 2). The mathematics anxiety mean score for the low SES group (M = 58.08, SD = 24.80) was higher than the middle SES group (M = 52.81, SD = 21.90) and the high SES group (M = 25). To determine whether there are differences in the mathematics anxiety scores based on participants' perceived SES and parental educational level, three Kruskal-Wallis tests were conducted. The first set of results indicated no statistically significant difference in the mathematics anxiety scores across the three SES groups, $\chi^2(2) = 5.650$, p = .059, with a mean rank score of 62.71 for low SES, 56.23 for middle SES, and 4.5 for high SES. Since there were only two participants in the high SES group, this group was merged with the middle SES group to see whether significant difference exists between the merged group and the low SES group. A similar result was obtained with no statistically significant difference in the mathematics anxiety scores between participants who perceived themselves as belonging to low SES and those who identified as coming from middle and high SES.

The results on the participants' parental highest educational level are displayed in Tables 4 and 5. The second set of results of the Kruskal-Wallis test indicated that there was no statistically significant difference in the mathematics anxiety scores with respect to mothers' highest educational level, $\chi^2(3) = 1.516$, $p = .679$. This result showed that, although the mathematics anxiety mean and the mean rank scores for participants with mothers in the lowest educational level were higher than those with mothers in the higher educational level, the differences in the mean and mean ranks for mothers at all educational levels did not differ significantly.

Table 4

Mothers'/Female Caretakers' Highest Educational levels During Participants' Elementary School Years

Highest Educational level	*n*	*M*	*SD*	Mean Rank	*df*	χ^2
Elementary or Less	15	56.07	20.87	61.90		
High School Graduate	69	51.53	23.58	52.99	3	1.516
Bachelor's Degree	25	53.96	19.84	59.10		
Not Applicable	1	41.00	-	42.50		
Total	110	52.61	22.21			

Note. One participant did not indicate mother's educational level in the survey and no participant reported master's degree as mother's highest education level. The mean ranks do not differ significantly at $p < .05$.

On the other hand, the third set of results showed that there was a statistically significant difference for fathers' highest educational level, $\chi^2(3) = 7.933$, $p = .047$ (see Table 5). The Kruskal-Wallis post hoc pairwise comparisons test (automatically produced by SPSS software at p < .05) indicated a significant difference between the following father's educational level groups: *Elementary or Less* and *Master's Degree and Above*, as well as *Bachelor's Degree* and *Master's Degree and Above*, but no significant difference between any other groups.

Table 5

Fathers'/Male Caretakers' Highest Educational levels During Participants' Elementary School Years

Highest Educational Level	*n*	*M*	*SD*	Mean Rank	*df*	χ^2
Elementary or Less	26	56.73	21.28	59.29*		
High School Graduate	55	51.31	22.68	49.71	3	7.933
Bachelor's Degree	17	62.84	23.84	66.18*		
Master's Degree and Above	8	39.50	12.09	33.81*		
Total	106	53.60	22.42			

*significant at $p < .05$

In order to report the effect size, three Mann Whitney U test were conducted on the groups with noted significant differences. The results revealed a statistically significant difference in the mathematics anxiety scores between elementary or less and master's degree and above groups ($U = 47$, $Z = -2.315$, $p = .021$, $r = .40$), and bachelor's degree and master's degree and above groups ($U = 29.5$, $Z = -2.244$, $p = .025$, $r = .45$). The magnitude of the differences in the mean ranks was found to be moderate in both cases. These results indicated that participants with fathers in the lowest educational level experienced higher mathematics anxiety than those whose fathers had higher levels of education, specifically graduate degrees.

Research Question 2

In order to answer the second research question, "What are the types of mathematics teaching anxiety that are experienced by in-service elementary school teachers?" participants were asked whether they experienced mathematics teaching anxiety (item #12 on the demographics questionnaire). Of the 110 participants who responded to the question, 38 (34.5%) answered "Yes," while 72 (65.5%) answered "No". Subsequently, MATAS-E score of mathematics teaching anxiety was calculated for each participant. The ten negatively worded items on MATAS-E were reverse-coded following the instruction from the SPSS manual, after which participants' responses to each item were added to obtain their total mathematics teaching anxiety scores. The higher the participant's total score, the higher was the mathematics teaching anxiety they experienced. Table 6 presents the descriptive statistics of MATAS-E scores for 111 participants. The result showed that the MATAS-E scores ranged from 23 to 87 with none of the participants obtaining the highest possible score of 115. The overall sample mean and the median (M = 50.68, Mdn = 51.0) were close to each other. A Shapiro-Wilk test ($p < .05$) indicated that the MATAS-E scores were not normally distributed. A positive skewness value of .098 and negative kurtosis value of -1.08 were noted (see Figure 3), suggesting a non-normal distribution of the mathematics teaching anxiety scores that was relatively platykurtic.

Table 6

Descriptive Statistics of MATAS-E Scores (N = 111)

Descriptive Measure	Value
Mean	50.68
Std. Error of Mean	1.727
Median	51.00
Mode	23.00
Std. Deviation	18.20
Skewness	.098
Std. Error of Skewness	.229
Kurtosis	-1.083
Std. Error of Kurtosis	.455
Minimum	23
Maximum	87

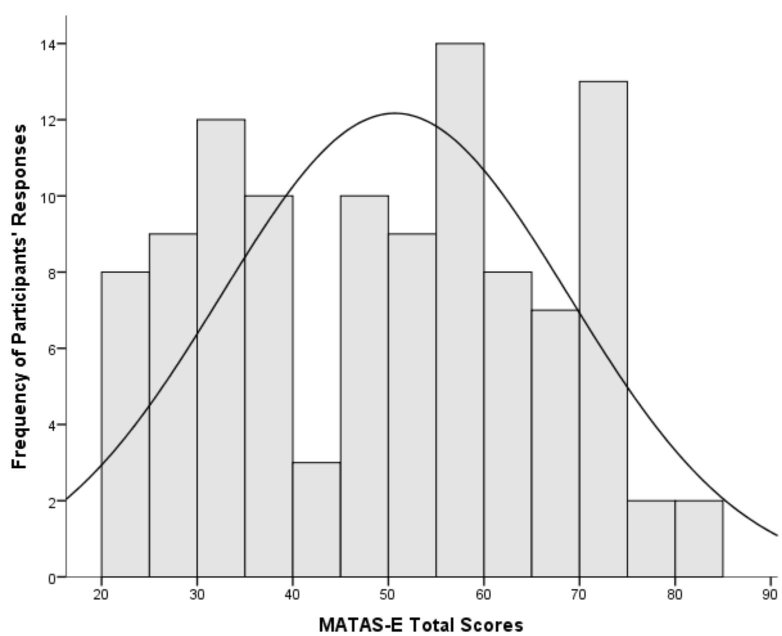

Figure 3. The distribution of participants' mathematics teaching anxiety scores as measured by MATAS-E.

Further investigation into the types of mathematics teaching anxiety that participants experienced (see Table 7) showed that the mean score of mathematics teaching anxiety due to subject knowledge was the highest (*M* = 18.59, *SD* = 7.57) while the mean score of mathematics anxiety due to teaching knowledge was the lowest (*M* = 7.06, *SD* = 2.73) for the whole sample. However, since the subcategories of mathematics teaching anxiety contain unequal number of items (that is, subject knowledge = 10 items, self-confidence = 6 items, attitude towards teaching mathematics = 4 items, teaching knowledge = 3 items), the mean scores for each of the subcategory were calculated. The result indicated that overall participants experienced more mathematics teaching anxiety due to self-confidence than the other three types of mathematics teaching anxiety (that is, subject knowledge, attitude towards teaching mathematics, and teaching knowledge).

Table 7

Results for Types of Mathematics Teaching Anxiety Experienced by Participants (N=111)

MTA Factors	Min	Max	*M*	*SD*	*Subscale Mean*
Subject knowledge	10	35	18.59	7.57	1.86
Self-confidence	6	29	15.67	6.32	2.61
Attitude towards Teaching Mathematics	4	20	9.36	4.18	2.34
Teaching Knowledge	3	15	7.06	2.73	2.35

Note. MTA = mathematics teaching anxiety.

Additionally, five Mann-Whitney U tests were conducted on each of the four subcategories of mathematics teaching anxiety to see whether there were differences in relation to the gender of the participants. The effect size (r) was calculated when significant differences were found in the MATAS-E subcategories' scores between genders. Table 8 displays the results on the comparison of male (n = 20) and female (n = 87) mathematics teaching anxieties. There were significant differences between the mean rank scores of males and females on MTA due to subject knowledge (U = 501.5, Z = -2.962, p = .003, r = .29) and self-confidence (U = 515, Z = -2.844, p = .004, r = .28). The magnitude of the differences in the mean ranks was small (effect size r = .29 and .28, Cohen, 1988) for the two subcategories of mathematics teaching anxiety. However, no significant differences were found between the mean rank scores of male and female participants on MTA due to attitude towards teaching mathematics (U = 645.5, Z = -1.809, p = .070) and teaching knowledge (U = 712.5, Z = -1.273, p = .203). These results indicated that mathematics anxiety due to subject knowledge and self-confidence were significantly higher in female participants than their male counterparts and that the two groups did not significantly differ in the mathematics teaching anxiety due to attitude towards mathematics and teaching knowledge.

Table 8

Comparison of Mathematics Teaching Anxiety Scores of Male and Female Participants (N = 107)

MTA Type	Gender	Mean rank	*Z*	*p*	*r*
Subject Knowledge	Female	58.24	-2.962	.003*	.30
	Male	35.58			
Self-confidence	Female	58.08	-2.844	.004*	.30
	Male	36.25			
Attitude Towards Teaching Subject	Female	56.58	-1.809	.070	
	Male	42.78			
Teaching Knowledge	Female	55.81	-1.273	.203	
	Male	46.13			

Note. * significant at p = .05

Research Question 3

The question-"What is the relationship between mathematics anxiety and mathematics teaching anxiety among in-service elementary teachers?"- was answered by calculating a non-parametric correlation, Spearman's Rank Order Correlation (rho or r_s), between mathematics anxiety and mathematics teaching anxiety. The range of correlation coefficient is from -1 to +1, where the sign indicates the direction of the relationship and magnitude refers to the strength of the relationship between two variables. According to Nardi (2006), *r* values below .30 are deemed to be weak, .30 to .70 are regarded as moderate, and above .70 are considered as strong. The result of the analysis revealed a statistically significant, strong positive correlation (r_s = .72,

$p < .01$, $n = 107$) between mathematics anxiety and mathematics teaching anxiety, with high levels of mathematics anxiety associated with high levels of mathematics teaching anxiety and low levels on one associated with low levels on another variable. This result, as supported by the scatterplot (see Figure 4), indicated that, as mathematics anxiety scores increased the mathematics teaching anxiety scores also increased and that participants with low levels of mathematics anxiety experience lower levels of mathematics teaching anxiety while those with high levels of mathematics anxiety have much higher levels of mathematics teaching anxiety.

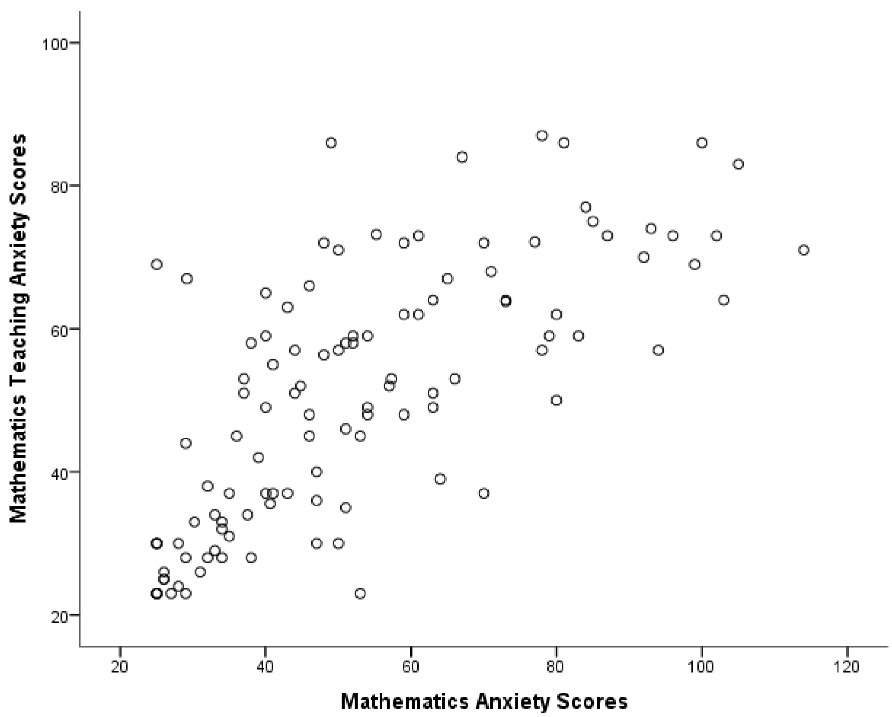

Figure 4. Correlation between participants' mathematics anxiety and mathematics teaching anxiety scores.

Furthermore, a crosstab comparison of participants' responses to questions related to mathematics anxiety and mathematics teaching anxiety was conducted to determine the number of participants who experienced both mathematics anxiety and mathematics teaching anxiety. The result, illustrated in Figure 5, showed that of the 110 participants, 46 (41.8%) reported that they experienced only mathematics anxiety, one experienced only mathematics teaching anxiety, 37 (33.6%) experienced both mathematics anxiety and mathematics teaching anxiety, and 26 (23.6%) did not experience either mathematics anxiety or mathematics teaching anxiety.

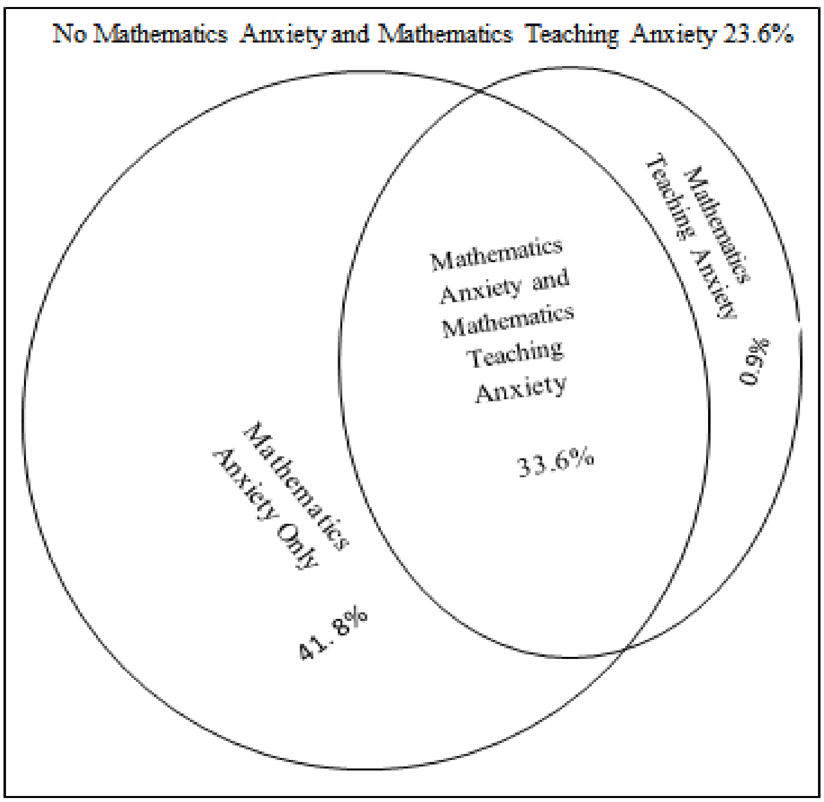

Figure 5. Comparison of number of participant who experienced mathematics anxiety (MA) and mathematics teaching anxiety (MTA)

Moreover, a crosstab comparison was performed using the result obtained from the demographic questionnaire to determine the number of participants with different levels of mathematics anxiety who experienced mathematics teaching anxiety (see Table 9). The result indicated that participants' with varied levels of mathematics anxiety also experienced mathematics teaching anxiety.

Table 9

Comparison of Mathematics Teaching Anxiety with Levels of Mathematics Anxiety

Experience of MTA	Low MA Level	Moderate MA Level	High MA Level	Total
Yes	1	21	16	38
No	18	49	5	72
Total	19	70	21	110

Additional examination of the category of participants in the three mathematics anxiety levels (low, moderate, and high) yielded significant group differences, $\chi^2(2) = 46.663$, $p < .001$, in the mathematics teaching anxiety scores when the Kruskal-Wallis test was performed. The post hoc pairwise comparison indicated that the mean rank score for the low mathematics anxiety group (M = 31.53, Mean rank = 21.24) was significantly lower than for the moderate group (M = 49.98, Mean rank = 55.04) and the high group (M = 70.34, Mean rank = 90.69). The results also showed that the moderate and high mathematics anxiety groups differed significantly in mathematics teaching anxiety scores. The Mann-Whitney U test was used to calculate the actual differences in the rank mean scores of the mathematics anxiety groups. The effect sizes for low and moderate mathematics anxiety groups was .5, (U = 199, Z = -4.704, N = 90, $p < .001$); low and high mathematics anxiety groups was .79, (U = 14.5, Z = -5.023, N = 40, $p < .001$); and moderate and high mathematics anxiety groups was .53, (U = 202, Z = -5.058, N = 92, $p < .001$). Thus, the effect sizes between the groups were considered as high (Cohen, 1988).

Other results from the demographic questionnaire. Participants were asked if they had ever experienced mathematics anxiety and at which stage in their education they first experienced it. Of the 110 participants, 23 (20.9%) responded that they first experienced mathematics anxiety at elementary school, 17 (15.5%) at middle school, 45 (40.9%) at high school, 4 (3.6%) at the university, while 7 (6.4%) did not remember when they first experienced mathematics anxiety and 14 (12.7%) responded that they had never experienced mathematics anxiety. The numbers and percentages of participants that first experienced mathematics anxiety at various grades and levels of education are displayed in Figure 6. This result showed that majority of the teachers in this study first experienced mathematics anxiety at the high school level.

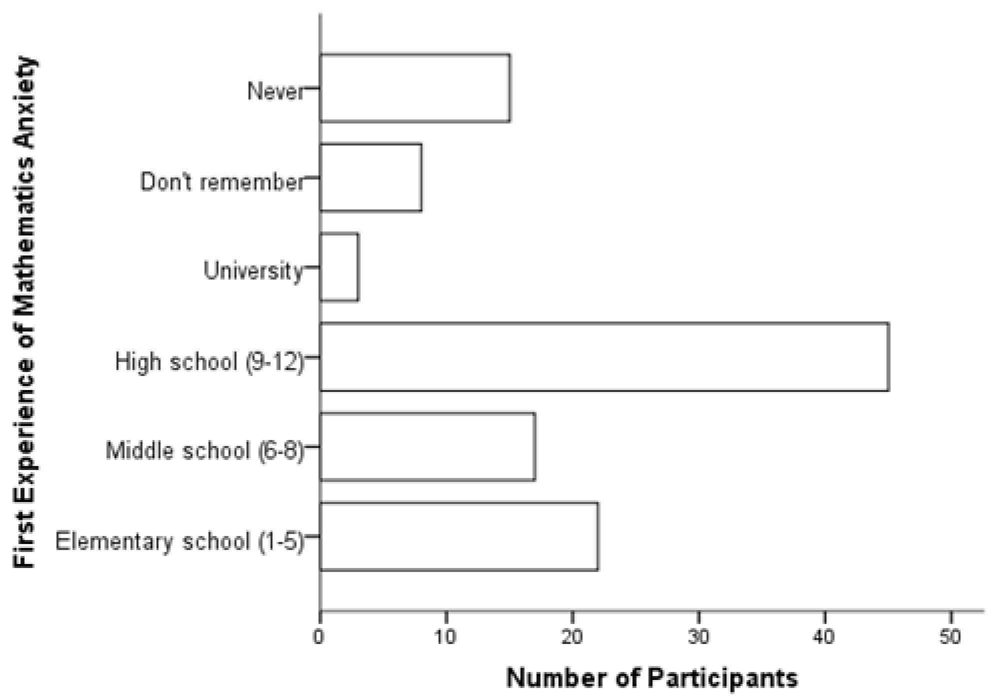

Figure 6. Education level at which the participants first experienced mathematics anxiety

In order to compare the differences in mathematics anxiety scores in relation to the highest level of mathematics studied by participants, a Kruskal-Wallis H test was conducted. Table 10 presents the results indicating statistically significant differences in mathematics anxiety scores across the five groups, $\chi^2(4) = 12.589$, $p = .013$. The Kruskal-Wallis post hoc pairwise comparison test showed a significant difference in scores for the Grade 10 group and the University group with a moderate effect size of .43 ($U = 19.5$, $Z = -2.932$, $N = 46$, $p = .003$). There was no significant difference between any of the remaining groups.

Table 10

Comparison of Participants' Mathematics Anxiety Scores across Highest Mathematics Studied in School

Highest Mathematics Course Studied	*N*	*M*	*SD*	*Mean Rank*	*df*	χ^2
Grade 10	5	78.20	14.53	91.60*		
Grade 11	11	61.89	17.69	72.82		
Grade 12	51	52.63	23.49	54.65	4	12.598
College	2	63.00	42.43	62.75		
University	41	46.93	19.64	47.16*		
Total	110	52.78	22.37			

Note. The mean rank in the Grade 10 row differs significantly from the mean rank in the University row at p < .05

Furthermore, participants were asked about how long they had been teaching at the elementary school (that is, grade 1-8). Analysis of their responses showed that 76 (69.7%) had more than 10 years of teaching experiences at the elementary schools, whereas 7 (6.4%) had 1-3 years of teaching experiences (see Figure 7). Also, 8 (7.3%) and 18 (16.5%) of them had 4-6 years and 7-10 years of teaching experiences respectively.

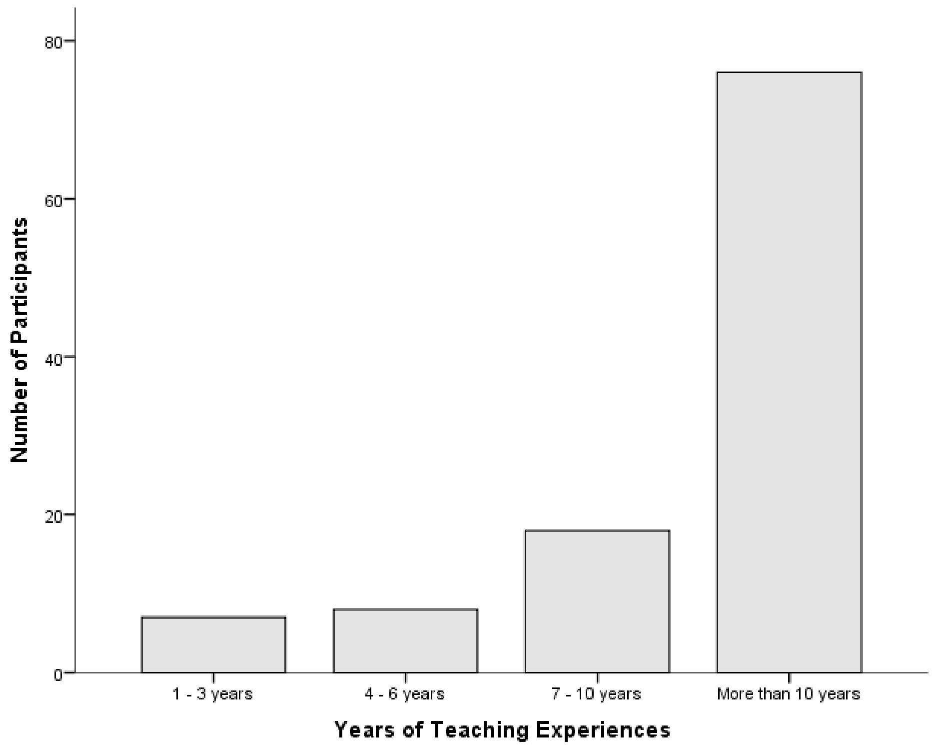

Figure 7. Participants' number of years of teaching elementary school grades (that is, 1 to 8)

For the purpose of further analysis, and following Melnick and Meister (2008), a three years cut off point was used to classify participants into beginning and experienced teachers. Thus, those who taught for 1-3 years are regarded as "beginning" teachers while those that taught for 4-6 years and 7-10 years are merged to form a single group referred to as "experienced" teachers. For further differentiation in teaching experiences, participants who taught for more than 10 years are referred to as "very experienced" teachers. The Kruskal-Wallis one way analysis of variance was used to compare the differences in mathematics anxiety scores and mathematics teaching anxiety scores between beginning, experienced, and very experienced groups of teachers. The first set of results showed that there was no statistically significant difference, $\chi^2(2) = 3.718$, $p = .156$, in the mathematics anxiety scores of beginning (mean rank = 76.43), experienced (mean rank = 50.71) and very experienced (mean rank = 54.49) groups. The second set of results, after the post hoc Kruskal-Wallis pairwise comparisons test was performed, indicated statistically significant differences, $\chi^2(2) = 7.296$, $p = .026$, between the groups(beginning and experienced as well as beginning and very experienced teachers) on levels of mathematics teaching anxiety. In an effort to determine the effect size, two Mann Witney U tests were performed. The results showed that mathematics teaching anxiety score was statistically significantly higher in the beginning group than in the experienced group, $U = 32.5$, $Z = -2.578$, $p = .01$, with a moderate effect size, r = .45. Additionally, the mathematics teaching anxiety scores of the very experienced group were statistically significantly lower than for the beginning group, $U = 109.5$, $Z = -2.566$, $p = .01$. However, the effect size, r = .28 for this test was found to be small (Cohen, 1988).

Additionally, participants were asked about their perceived level of understanding of grades 1-8 mathematics concepts and the materials that they teach (item #15 on demographic questionnaire). The majority of the 100 participants who responded, 68 (61.8%), rated themselves as having high understanding of mathematics concepts and the material they teach. Two (1.8%) and 40 (36.4%) perceived themselves as having low and moderate understanding respectively.

Phase 2 (Qualitative Follow-up Phase): Results from Interviews

As previously explained in Chapter Three, the follow-up qualitative phase of this study was employed to provide a better understanding of the reasons behind the mathematics anxiety experienced by in-service elementary school teachers and to explain the results that were obtained from the previous quantitative part (Gay et al., 2009; Tashakkori & Teddlie, 2009).

Participants were purposefully selected based on their mathematics anxiety scores and responses on the demographic questionnaire, which included whether they overcame, reduced, or coped with mathematics anxiety. Their perceptions of the causes of their mathematics anxiety and its impact on their personal and professional lives were explored. Individual interviews with the participants were digitally recorded and transcribed by the researcher. The transcripts were analyzed using thematic analysis as outlined by Braun and Clarke (2006). The qualitative research question that was addressed through the interviews was “What are the self-reported causes of mathematics anxiety among elementary school teachers and what strategies did they use to cope with, diminish, or overcome it?” The following section provides a detailed analysis of participants’ responses.

Four in-service elementary school teachers participated in the one-to-one interview (one male, three females). Two of them were classroom teachers for grades 1 and 2 (split class), one grade 6 teacher, and one grade 7 and 8 (split class) teacher. All the participants had taught mathematics for more than 10 years, therefore were in the ‘very experienced’ group. Each participant was assigned a fictitious name for confidentiality. Table 11 presents the background information about the participants.

TABLE 11

Summary of Background Information about Participants

Name[1]	Ron	Abby	Cindy	Rita
Gender	Male	Female	Female	Female
Race/Ethnicity	White	White	Multiple Ethnicity	Asian/Pacific Islander
Family's Socioeconomic Status (SES)	Middle SES	Low SES	Low SES	Middle SES
Mother's Highest Degree	High School Diploma	High School Diploma	High School Diploma	Bachelor's
Father's Highest Degree	High School Diploma	High School Diploma	High School Diploma	Bachelor's
Highest Mathematics Studied	Grade 12	University	University	Grade 10
Years of Teaching Experience	More than 20 years	19 years	18 years	More than 20 years
First Experience of Mathematics Anxiety	Elementary School (Grade 5)	Middle School (6-8)	High School (Grade 11)	Middle School (Grade 6)
Perceived Mathematics Anxiety Level	Low	Low	Low	Low
Measured Mathematics Anxiety Level	Low	Moderate	High	High

[1] All participants' names are fictitious.

Major Themes from the Face-to-Face Interviews

Positive early experiences. Participants' responses in the interviews indicated that prior to them experiencing mathematics anxiety, they had positive experiences related to mathematics at some points in their early lives, particularly in the primary grades (1-3). For example, Ron expressed that he "felt confident [in math] at the primary grade, grasped the concepts fairly quickly and enjoyed it." Rita said "I love math because my father was a mathematician…and my excitement will always be there for math." Cindy responded that "right at the beginning, I did enjoy math like primary grade 1 to 3." Abby said she "felt successful" and "felt prepared" in mathematics. Subsequently, they responded to the first part of research question #4 (that is, 'what are the self-reported causes of mathematics anxiety among elementary school teachers?') and described the causes of their mathematics anxiety and its impact on their personal and professional lives. Two main themes emerged from the interview responses as the causes of mathematics anxiety that the participants experienced. These are i) their teachers' teaching strategies, insensitive comments, and "mean" behaviour; and ii) their own (participants') lack of understanding of mathematics concepts. These themes are elaborated on in the further text.

Teachers' teaching strategies, insensitive comments, and "mean" behaviour. Two of the participants commented on teachers' teaching strategies that were tailored towards their peers who excelled in mathematics, as the cause of the mathematics anxiety that they experienced. Teachers' insensitive comments and mean behaviour also led to the development of some of the participants' mathematics anxiety. For instance, Abby explained that she was afraid of mathematics when growing up. She said that her teachers could have helped her along the way but that they "assumed we knew everything and didn't, maybe, review everything." She described her experience in mathematics class as one where "sometimes I felt the teachers were just going at the speed of strong students, not at the speed of some other students and you didn't always want to ask questions because sometimes you didn't know what to ask." Her Grade 11 mathematics teacher who told her "don't take grade 12 math, you won't get into university because you struggle [with math]," further discouraged her.

Cindy explained that she had positive experiences in mathematics class until she got to high school. She stated, "when I got to high school, Grade 9 was good, Grade 10 was good; by Grade 11, I felt like I was struggling, I felt burdened,…, math was my faultiest by a long shot and I struggled with it a lot." Although Cindy said that her teachers did their best to make her enjoy mathematics, she voiced her dissatisfaction about their teaching strategies. She said that they, "teach the top of the class and they leave other people behind."

Unlike the other three participants, Rita grew up in a cultural environment that was different from the Western world. She recalled an event that contributed to her development of mathematics anxiety at grade 6. She said:

> At Grade 6 level, I had a teacher who, after making mistakes in math, would hit me with a ruler at the back of my hands. I started dreading math period and that was the time my heart went away from math. Whole year long I was afraid to face the teacher and the class. I will be all the time scared that if I make mistakes, I will be beaten…Now I see that all she had to do was I was not understanding how to solve the same [math] problem, three times she had to explain to me, three time I could not understand, she could have used some math manipulatives and some other stuff to develop my understanding; to know where I am making mistakes and how I can fix them.

It appeared that Rita's teacher was frustrated by her lack of understanding of the mathematics problem, which resulted in the mean behaviour. Although the mean behaviour of

Rita’s teacher is prohibited in Canada (e.g., in 2004 the Supreme Court of Canada ruled that corporal punishment is forbidden in schools), it is still not uncommon to experience such behaviour from teachers in some other cultural contexts.

Ron did not mention teachers as the source that caused the development of his mathematics anxiety as he responded that “In grade 5 and 6, I really noticed that math was a struggle for me…it wasn’t anything the teacher was doing, I just think where I was at, as a kid, school wasn’t a major interest for me.” However, he acknowledged that teachers could contribute to the development of mathematics anxiety in students when he said:

> I have witnessed teachers who are not comfortable teaching math and that comes across to their students and those students go on with that same anxiety to the next level and those are the students saying that ‘I’m not good at math’, ‘I don’t get it’, ‘I’m never going to get it’.

Participants’ responses showed that teachers actions; that is, how they carry out their daily mathematics teaching, what they say to students, and their behaviour could influence students’ mathematics anxiety or contribute to the development of mathematics anxiety in students.

Participants’ lack of understanding of mathematics concepts. Three out of the four participants who were interviewed explained that their mathematics anxieties were due to lack of understanding of mathematics concepts at some points in their lives; which resulted in poor performance in mathematics, as they could not do well in the subject. For example, Abby said that:

> As the junior level mathematics got hard with more word problems, I remember I couldn’t understand word problems. And then in intermediate, grade 8, I remember

> thinking that there were too many dots that weren't connected for me and I had gaps and found it difficult to be successful and I just got through in high school. So, there were areas I was able to memorise and I could do well and if I had to apply it I couldn't… I don't feel like I have a really strong background even though I have completed graduate stat, I have completed high school math. It just doesn't come naturally to me.

Cindy explained that mathematics "just didn't stick" with her. She expressed her lack of understanding of mathematics concepts when she said: "I guess when you have to use the formula and try to figure out the numbers, I just couldn't do that, it wasn't making sense to me…I didn't understand math, so it's just, whatever I could do, I would do." She also felt that she would have exceled in high school mathematics in an applied class, however, at that time the option to go into an applied class was not available for students. She said that, "in those days we didn't have an option of applied; it was advanced. And I was going to [school named] when it was private, so it was like, it was assumed you were going to go into some kind of career, but really? I should have taken applied [class] then, I'm sure I was an applied student."

Ron, due to lack of interest in school, devoted less time and effort to mathematics in his early years of school, which contributed to development of mathematics anxiety. He explained,

> In grades 5 and 6, I really noticed that math was a struggle for me, as you start to fall behind, that anxiety increases, right? I am not getting this, so therefore the next subject that I'm going to be taught, I'm not going to be able to get that and that's when I noticed that my anxiety was at the highest level…and then because you come into the class not prepared for the next day, you don't have your homework done, you haven't done the studying for the test, your level of anxiety increases because you know you are not going to do well, you are going to have to bring it home to your parents.

It was evident in the participants' responses that lack of understanding of mathematics concepts contributed to their mathematics anxiety with the exception of one of them (Rita) who mentioned that she was encouraged and helped by her father who was a mathematician. Rita recalled her father's support in the learning of mathematics as she said: "during summer vacation my father used to make me finish the whole entire [coming] year's syllabus at home. When the year started, I knew most of the things and when the teacher read them I was comfortable because I had prior knowledge to the same thing".

Lack of parental support in mathematics. Three of the participants expressed that they did not get any extra help from their parents as they struggled with learning mathematics in school. Their parents did not provide them with mathematics-related support such as tutoring and extra-curricular activities in the subject. They seemed to have relied on themselves and the help they received from school. For example, Abby stated that:

> Kind of typical back then where parents did not do homework with you and I spent a lot of time on my own and so… you kind of learned incidentally how the world works mathematically, we knew we did not have computers, we did not have tutoring in form of pushing and it was more you have to do things on your own and so you have to know your math.

Similar to Abby, Cindy recalled that she did not receive any encouragement from her parents to learn mathematics. She commented:

> My parents were high school graduates, so they never really pressured us about academics…We played organized sports, we took music classes when I was a kid but we

> didn't get involved in like more academic things…My parents couldn't help me, they didn't understand (math), they were like, "go to school, go to find out, ask the teacher."

Unlike Cindy, Ron's received some support from his parents as they encourage him to excel academically. He said that "my parents pushed, you know they encouraged us [my siblings and I] academically". However, the parents did not provide him with any form of tutoring or activities that could promote his learning and understanding in mathematics.

From participants' responses, one could say that lack of parental support in mathematics seemed to have an influence on three of the participants' learning and success in mathematics, whereas adequate support from parents in mathematics helped to promote Rita's understanding, and likeness for mathematics.

Teachers' and/or parental influences and interaction. This section provides answers to the second part of the fourth research question, that is, 'What strategies did participants use to cope with, diminish, or overcome mathematics anxiety?' Two of the participants claimed that they overcame their mathematics anxiety, while the remaining two said that they had reduced their mathematics anxiety and were able to cope with it. One of the latter still experiences mathematics anxiety when it comes to advanced mathematics. Three participants specifically mentioned teachers as being helpful in overcoming and reducing their anxiety for mathematics, while one of them acknowledged her parents and teachers as responsible for overcoming her mathematics anxiety. The participants, eventually, overcame, reduced, or coped with mathematics anxiety through the influences of their teachers and/or parents. For instance, Ron overcame his mathematics anxiety with the help of one of his teachers. He explained,

> My grade 7 teacher was really good at diminishing that. She slowed everything down, she re-addressed the basic concepts of math and she let us kind of function at our own pace

> until we got to where she knew we were comfortable with continuing on and pushing in the more difficult concepts….after that, I really didn't experience any feeling of anxiety or tribulation on completing anything.

Cindy's teachers helped her cope with her struggles with mathematics and the mathematics anxiety that she experienced in high school. Although she continued to avoid high level mathematics, she expressed that,

> I had wonderful teachers. They always gave me extra help. They were very supportive…Especially in grade 13, I took calculus and my teacher was incredible. He would spend every day after class and he would explain [math] to me.

Cindy also "worked with partner and tried to understand mathematics" to reduce her anxiety. She felt that due to her lack of abilities to learn mathematics at a higher level, she would "probably not" be able to teach mathematics at grade 7 and above. She felt more comfortable teaching lower grades and does not experience mathematics anxiety over teaching those grades.

For Abby, she started to make sense of and felt confident in mathematics with the help of her teacher when she was about 20 years old. She recalled "thinking the teacher had a lot to do with it. It was the way it was presented and even the voice of the teacher was very calming."

Unlike Abby and Cindy who received no support from their parents in relation to mathematics, Rita overcame her anxiety for mathematics and regained her fondness for the subject with the help of her father and a teacher. She said:

> My father, since his subject was math, he took that fear out of me, helped me, and guided me…I found my grade 7 teacher to be very nice and very polite, very friendly. I found that with the help of the teacher, and given her respect and love towards me, I was doing well in my math period. The classroom atmosphere was very comfortable.

Effects of mathematics anxiety on participants' approaches to teaching. It appeared that the experience of mathematics anxiety had positive effects on the participants as they made efforts to ensure that their students do not have similar negative experiences as they had in mathematics classes. According to Ron, the experience of mathematics anxiety made him realise that, "there are kids that experience anxiety with regards to mathematics" whether they show it or not. This awareness made him teach mathematics differently by avoiding traditional methods, using humour, creating positive classroom atmosphere, and admitting his prior mathematics anxiety to his students. In his own words he said:

> I look at myself at grades 5 and 6 level, I remember the anxiety that I experienced, I remember the feeling of not knowing and hoping the teacher never called on me, and so I teach math from that perspective. I know my kids are all at different levels…I try to meet every kid at where they are at and I try to reduce the anxiety for those kids that are coming and going. "I'm not good at math"; …And I take it slow, I do lots of examples, I use Internet as much as I can for videos, so that kids can see it happening in front of them. I use real word problems so that they can connect to the math that I'm doing and I think that, coupled with the atmosphere that I have in my classroom that don't be afraid to make mistakes, nobody is gonna laugh at you, nobody is going to make fun of you…I like to use humour to kind of break the ice and to say "you know what, math is a serious subject but it's not that serious."… I tell them right from the get go that I struggled with math when I was in school but I overcame it and I knew that with some time, with some effort and some practice, that this wasn't that big of a deal, I can figure it out and I did. I think that [students] seeing that personal connection that "hey he did too and look now,

> he can teach it without any problem, he explains it well." And I think coming from that perspective helps me explain it so that kids can understand [math].

Similar to Ron, Cindy said that her experience with mathematics anxiety had a positive effect on her as she taught in such a way that her students are encouraged and feel successful in mathematics. She said:

> I feel more sensitive to my students making sure that they have successes along the way, to encourage them to like it [math], to understand it by making it more applied for them…I try to mix things up a lot, we do some practical things and we do some things on paper. Because I know I have x-number of different styles of learning, so many different levels that they are at, so I have to kind of put through with a multitude methods of teaching… I know how to address it [math] with them; how to kind of make it more fun, more interactive, make it more practical so it doesn't scare them so much. We do things in small pieces and they can experience the success and they feel confident to move on.

Abby also explained that her mathematics period was her favourite period; "I feel like I'm learning with the students. I get to have the second chance again [laughed], only I'm in charge [laughed]," she said. She was very enthusiastic about her teaching methods which she described in the following way:

> I want to make sure students have enough time doing math; math drills, short videos, discussion, manipulatives, get up, move around, go to your small groups, get on the floor with chalk paper, talk to your big groups…I talk with the students asking them. "did you understand that? Okay, what did you learn today or if you are to put a title on today's note what would you call it?"...I go back a couple of years and remind them, because that wasn't done for me.

Similar to Abby, the experience of mathematics anxiety also had a positive impact on Rita's teaching. This became apparent when she expressed that, "when I started teaching, I did make it a point that I would never, never use such method [that included teacher's mean behaviour] to teach my students." She explained that she tried to make her students "understand, enjoy, and try new things in mathematics." She makes use of "manipulatives and prepare[s] some special lessons for the student to do during the recess periods or after school sometimes to make his/her understanding clear," and to show her students that "math is fun and math is a game." She also "seeks and finds whether the student is relaxed in the math period or not."

As previously stated, it seemed that the experience of mathematics anxiety motivated the participants to be more sensitive to students' needs in learning mathematics. Other results from the interviews, which include the negative effects of mathematics anxiety on participants, their opinions on transfer of mathematics anxiety from teachers to students, the support that could be put in place for teachers who are experiencing mathematics anxiety, as well as the advice that could be given to a teacher who may be experiencing mathematics anxiety are hereby discussed.

Negative effects of mathematics anxiety on participants. The participants' recounted the personal negative effects that accompanied the feelings of mathematics anxiety that they experienced at the period they experienced it. For instance, Ron said that his, "attitude towards mathematics changed," as he was not doing well in mathematics. Cindy felt "inferior" among her peers and lost confidence in her mathematics abilities. Feelings of inferiority and peer pressure became obvious when she recalled one of the events where she experienced mathematics anxiety. She said that:

> In grade 11, I took physics and I was in physics class with very, very intelligent people. They are all doctors now. So, I felt very inferior and I didn't get it and truly did not and I

> was taking it because I had to. And the math was just like I said, I did what I had to do to pass the class…I was comparing myself to my peers so we have the doctors and lawyers who are succeeding and they are getting A's and you are somewhere down around the C's you feel very inferior right off the bat.

Cindy's avoidance of mathematics and lack of confidence in her mathematics abilities surfaced when she responded:

> I think that because I have feelings of not being successful in math, I will never pursue something that's related to math. I will take math courses if I have to, but it's out of necessity; but I would never seek it out on my own and wouldn't put myself in a position where I will be responsible for something like that…I don't go out of my way to find situations where I have to use math… I will never need to do calculus. I know how to use numbers as far as like finances, planning things, I can do things practically, but that's where it stops.

Similar to Cindy's, Abby's confidence in mathematics was also affected. She could not ask the "teacher to slow down" as she "didn't understand at the speed of the really strong students." She felt as if she was not part of the class, and further explained:

> You feel because you don't understand math as well you are not part of that group. So, you don't apply for the same courses and programs they received. Also, the way school system was, I always thought those students were the really smart kids even though we know intelligence has all different flavours. I think back then, you just saw math as the measurement of intelligence.

Rita said that, "I was so scared to seek help…I just don't have the gut to go to the principal or someone else to let them know what is happening," indicating that her confidence was affected. She recalled other negative personal effect of mathematics anxiety on her, back then, when she said:

> Initially, at that year when I was in grade 6, I didn't feel like doing math homework, I didn't want to take part in math. Many times I knew the answer, I knew how to solve the math at the chalkboard when the teacher was talking to others but I never raised my hand and let others know that I knew it; my attitude changed, I started avoiding math.

Transfer of mathematics anxiety from teachers to students. Apart from the effect of mathematics anxiety, participants were asked whether a teacher's mathematics anxiety could be transferred to his/her students (Item #9). All of them answered "Yes" and elaborated to support their responses. Ron said:

> If students pick up on teacher's anxiety [over mathematics], they will feel anxious too, they will feel less confident and students are very perceptive, they know if you know the concepts, if you know the materials. And if you are not sure and you are struggling, students will pick up that and that will create feelings of uneasiness.

Abby felt that the teacher's attitude matters as it leads the class. She said, "I think intuitively students know whether you are just going through the motions or you love it [math]". Rita also said that "if the teacher is having mathematics anxiety, she won't have confidence to teach her students, and when you are lacking confidence, the students, believe it or not, one minute they know that the teacher is not capable of doing it [math]". Cindy not only stated that teachers could transmit anxiety to students, but also described the attitude and behaviour of those teachers in the classroom. She said:

> If you don't feel confident in teaching it [math], you are going to teach it less. You may not put into it the same amount expertise or effort you would have otherwise…for

> teachers who don't fully understand it [math] or are unable to explain it to their students, I can see them, maybe, dumbing down the questions so they are not as rich and therefore students aren't encouraged to try hard questions or try something that may be more challenging.

In essence, the participants felt that students would know if their teacher is having any form of uneasiness towards mathematics, and that they could get caught up with it and may, therefore, not have the opportunity to develop to their full potentials in mathematics.

Supports for teachers experiencing mathematics anxiety. Participants were also asked to provide suggestions on the support that should be put in place for a teacher that is experiencing mathematics anxiety (Item #8). They suggested effective professional development and workshops through the school board. Apart from this, Cindy stated that supports through the principal and other colleagues are also vital. Specifically, Ron said:

> Any professional development from people who are experts in the field is always beneficial. They are always looking at new ways to teach concepts, alleviate stress, and reduce anxiety in kids. If we don't have an introduction to those or if we are not taught those, we have so much going on in the day and in our lives that we miss a lot of these things.

Abby supported Ron's comment when she said:

> I want the workshops to be available through the board. I want that link between the math consultant and ministry and current research. I rely on that… Leading research around the world is saying this is how it should be, so the ministry uses that research and our consultants and superintendents interact with that, and then they take that to us. So, I embrace what they say, so I want them to keep doing that.

Apart from putting in efforts to learn mathematics, participation in mathematics workshops and events seemed to have contributed to the reduction in the mathematics anxiety that Abby experienced as she said:

> I kind of just buckled down and studied and did what I had to do to learn it [math]. As you mature, you realise you kind of work at it; it's not easy, you just have to put more work into it and you do what you need to do… [I like] going to the workshops, taking advantages of all the professional development that is informal and the formal professional development that I had to go to, I actively participate, I put my hands up and add comments. I love conversational discourse when other teachers are having a conversation or venting or offering suggestions.

The last question on the interview protocol asked participants to give advice to a teacher who may be experiencing mathematics anxiety (Item #10). Some of their suggestions included "seek for help"; "ask your colleagues for help", "don't be afraid to do that because they are more than willing to help you"; "you just have to get over your anxiety about it [math] and reach out for somebody because generally speaking someone would help"; "put a lot of work into it [learning mathematics]"; and "do not give up, that's the last thing you want to do, it's not gonna be good for anybody."

It appeared that the participants attached great importance and value to the findings from research on mathematics and thought such research would help them in their practices and development as professional teachers. Their responses showed that professional development and workshops centered on the teaching of mathematics, including those aimed at alleviating anxiety, are needed by all teachers, including those that suffer from mathematics anxiety.

Overall, the participants attributed the causes of mathematics anxiety to their teachers' teaching strategies, insensitive comment, and mean behavior, and their own lack of understanding of mathematics concepts. The experience of mathematics anxiety had negative effect on the participants as it affected their confidence in mathematics and their attitude towards mathematics. These, for some of them, resulted in avoidance of mathematics courses and mathematics-related careers. Two of the participants experienced inferiority as learners of mathematics and felt excluded in mathematics class, while three of them lacked parental support for studying mathematics. The past experience of mathematics anxiety seemed to be partly debilitating for some of the participants, while they were students, and also enabling them as teachers. Leveraging on their prior personal experiences of mathematics anxiety, participants appeared to be motivated to teach mathematics using different teaching methods as opposed to traditional teaching methods and they became more sensitive to student's needs in mathematics. All the participants responded that they did not experience mathematics teaching anxiety and that they would ask for help from their colleagues and/or principal when they needed to. For example, Ron confidently stated that: "there nothing in math now that I look at and I kind of get worked up over how am I going to teach it. Anything that I'm teaching in grade [number] curriculum I've got a very good grasp of, I know a variety of ways going about teaching it to kids." The participants also seemed to prepare well for their mathematics lessons as this reflected in their responses. Abby said that she does "actively study" mathematics topics before she starts teaching them; Cindy expressed that she was "pretty prepared" before teaching mathematics; and Rita stated: "I research my work, a week before I make my [math] lesson plan."

In addition, all the participants supported the notion that mathematics anxiety can be transferred from teachers to students and provided suggestions for teachers who may be suffering from mathematics anxiety.

This chapter described the findings on the data collected through the online survey and the follow-up face-to-face interviews. The results from the survey were displayed with their corresponding tables and figures and the themes that emerged from the interviews with participants were explained. The next chapter discusses detailed summaries of the integrated findings from the quantitative and qualitative data and relates them to the literature and the theoretical framework for the study. It also contains the implications and limitations of the study, as well as recommendations and suggestions for future research.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

This study utilise a two- phase, sequential explanatory mixed methods design to provide a comprehensive presentation of mathematics anxiety and its relationship with mathematics teaching anxiety as experienced by in-service elementary teachers in Southern Ontario. Demographics factors, such as gender, socioeconomic status, and parental educational level, were compared among the participants to determine variations in their mathematics anxiety. In the first phase, statistical quantitative results were obtained from a sample of 111 elementary in-service teachers through an online survey. In the second phase, follow-up face-to-face interviews were conducted with four participants to help contextualize the results from the first phase, and to explore the causes of mathematics anxiety and how the participants coped with, reduced, or overcame anxiety over mathematics.

This concluding chapter contains the discussion of major findings from the quantitative and qualitative parts as they relate to the literature and the theoretical framework introduced in Chapter Two. It also includes the implications and limitations of the study, recommendations for improvement of practice, and suggestions for future research.

Summary of Findings

The discussion of findings which relate to the three research questions, *What are the levels of mathematics anxiety among in-service elementary school teachers and how do their anxieties differ in view of varied socio-cultural factors?; What are the types of mathematics teaching anxiety experienced by in-service elementary school teachers?;* and *What is the relationship between in-service elementary school teachers' mathematics anxiety and* *mathematics teaching anxiety?*, are presented first. This is followed by the discussion of findings on the fourth research question.

Findings related to mathematics anxiety. The findings from the online survey revealed that the participants in the study, all elementary school teachers, experienced different levels of mathematics anxiety. Out of the 111 respondents, approximately 17%, 64%, and 19% experienced low, moderate, and high mathematics anxiety, respectively. This finding is consistent with previous studies (Hadley & Dorward, 2011; McAnallen, 2010) that reported varying levels of mathematics anxiety among elementary school teachers. For example, McAnallen (2010) reported that of 261 elementary in-service teachers in her study, 48%, 46%, and 7% reported mild, moderate and severe mathematics anxiety. In addition, whereas some of the participants in this study perceived their current levels of mathematics anxiety to be low and moderate, their scores on the RMARS scales seemed to indicate high levels of mathematics anxiety. One explanation for this could be that either these teachers may not be totally aware of the extent of their anxiety for mathematics or they felt embarrassed to disclose their actual levels of mathematics anxiety.

In addition, the findings from demographic factors associated with mathematics anxiety revealed significant and non-significant results. First, many studies (Altermatt & Kim, 2004; Balogˇlu & Kocak, 2006; Brady & Bowd, 2005; Fuson, 2007; Hadley & Dorward, 2011; Hembree, 1990; Ho et al., 2000; Khatoon & Mahmood, 2010; Ma & Cartwright, 2003; Merritt, 2011; Muqdadi, 2006) have provided evidence in relation to gender differences in mathematics anxiety in favor of males. This study is no exception, as male participants showed lower mathematics anxiety than their female counterparts. Also, males' mathematics anxiety scores were only in the low and moderate categories. That is, none of the males' scores fell under high mathematics anxiety level. An explanation for this finding could be that males, in particular, may be wary about admitting to their fears of mathematics (Tobias, 1998). According to Sheilds (2006), women reported more mathematics anxiety perhaps because they have been "socialized to talk about their feelings more than men and [therefore] are more willing to admit their anxieties" (p. 38). Another explanation could be related to differences in the past mathematics learning experiences of males and females students which have been well documented by many researchers (AAUW, 1992; Jackson & Leffingwell, 1999; Jones & Dindia, 2004; Koehler, 1990; Sanders & Nelson, 2004; Tiedemann, 2002). Evidence has been provided that showed that differential teacher interaction and treatment of males and females within the mathematics classroom, usually in favour of males, influence the learning of mathematics. In Jackson and Leffingwell's (1999) study, gender bias was reported as girls were mocked more often than boys; and boys received more explanations and help than the girls when they had difficulty with mathematics problems, irrespective of their abilities in mathematics. Gender bias in mathematics could also be related to cultural norms and stereotypes perpetuated by some parents, teachers, as well as the society. These groups have different beliefs and expectations for girls and boys, including the beliefs that "boys are more capable in mathematics than girls" and that "careers related to mathematics are suitable only for males." For instance, Jacobs et al.'s (2005) study found that parents seemed to have higher perceptions of their sons' mathematics abilities than those of their daughters', and that they provided more mathematics-supportive opportunities and materials for their sons than they did for their daughters. Such differential treatment of boys and girls at home and in school could hinder females' performance in mathematics and weaken their self confidence in mathematics abilities (Eccles, 1994). Also, the media seems to depict people, particularly females, who are skilled/talented in mathematics as exceptional, nerds, weird, or different (Arem, 2003). Apart from gender bias, in Canadian society, people frequently admit to mathematics illiteracy and get support from others who acknowledge similar deficiency in mathematics. This acknowledgement generates no social humiliation and brings about feelings of sympathy from others. This rarely happens to people who say "I cannot read" (Arem, 2003; Sheilds, 2006; Wieschenber, 1994). Acceptance of mathematics ignorance by the society could lead to the lack of effort and motivation to develop strategies that could be used to deal with the problem.

Secondly, the findings showed that there were no significant differences in participants' mathematics anxiety scores in relation to race and ethnicity, though the White group mean score was slightly higher than the Non-White group mean score. Although participants in this study were mostly White (87%) and the other ethnic groups were under-represented, the findings indicated that it is unlikely that mathematics anxiety could be predicted by the race and ethnicity of the participants. This finding is consistent with other studies, involving White and Black college students (Hembree, 1990); White and Black grade 7 students (Merritt, 2011); and adult students from different ethnic groups (Fuson, 2007), that reported no differences in mathematics anxiety with respect to race and ethnicity. However, one cannot neglect the likelihood that mathematics school experiences for White and non-White teachers could be different as evident in the cause of mathematics anxiety of the Asian participant that was interviewed (that is, use of corporal punishment). More Canadian research is needed to find out which of the two groups of teachers (White and non-White) is less likely to choose a teaching profession when they feel mathematics anxiety. Thirdly, there were no differences in participants' mathematics anxiety scores in relation to socio-economic status. A large number of the participants (87%) reported moderate socio-economic status during their school years, while some participants reported low

(11%) and a few reported high (2%) socio-economic status. However, two of the participants in the interview, one with a moderate score and the other with a score indicating high level of mathematics anxiety, expressed that they were from low SES and did not receive any help from their parents regarding extra-curricular activities in mathematics or extra learning opportunities in the subject when they were growing up. According to Catsambis (2005), parents of higher SES might provide more learning opportunities in academic subjects, including mathematics, for their children both at home and in school. In this sense, it appeared that provision of extra learning opportunities, such as tutoring, by the parents, could have helped the participants in filling the gaps in mathematics knowledge that they experienced at a younger age and this could have promoted their understanding of mathematics concepts. Little is known from the literature concerning the relationship or influences of socio-economic status on mathematics anxiety; thus, more research in this area is needed.

Lastly, the findings that participants' mathematics anxiety scores were not significant for mother's highest educational level was contrary to the Alexander and Martray's (1989) findings as college students who indicated mother's highest level of education as high school had significantly higher mathematics anxiety scores than those that had mothers with higher education degrees. However, regarding father's highest education level, this study found significant differences that supported Alexander and Martray's (1989) findings, where participants whose fathers were professionals had lower mathematics anxiety than those whose fathers were not professionals. Generally, through encouragement, parents play a role in lessening the effect of mathematics anxiety in their children (Scarpello, 2007). However, those with low educational attainment are likely to have little knowledge of mathematics concepts, may be less comfortable with mathematics, and may have a negative attitude towards mathematics that could result in mathematics anxiety and avoidance of mathematics (Geist, 2010). Thus, the parents' ability to support and provide a stimulating mathematics environment for their children is obstructed.

Findings related to mathematics teaching anxiety. Elementary school teachers in this study experienced different types of mathematics teaching anxiety. Specifically, male teachers seemed to experience less mathematics teaching anxiety due to subject knowledge and self-confidence, compared to their female counterparts. A similar finding was reported by Yazıcı and Ertekin (2010), where they found that mathematics teaching anxiety, due to subject knowledge and self-confidence, was higher in female pre-service teachers compared to males. The findings that females felt more mathematics teaching anxiety due to subject knowledge than males could be explained by the general belief that male students are better in mathematics than females by the time they finish their high school education. Teachers' differential treatment, as previously explained, plays a crucial role in the differences found in mathematics learning that favor male students (Geist, 2010).

The findings from this study also revealed a positive correlation between the two anxieties: as mathematics anxiety increases, mathematics teaching anxiety also increases. Also, there were significant differences in the mathematics teaching anxiety mean scores among participants with low, moderate, and high mathematics anxiety. Among these three groups, those with low mathematics anxiety had lower mathematics teaching anxiety scores, while those with high mathematics anxiety had the highest mathematics teaching anxiety scores. A similar result was reported by Hadley and Dorward (2011) in their study with grades 1 to 6 teachers, where they found a positive relationship between anxiety about mathematics and anxiety about teaching mathematics. These researchers indicated that teachers who were anxious about mathematics were likely to be anxious about teaching mathematics.

In addition, the findings from this study supported one aspect of the notions concerning the relationship between mathematics anxiety and mathematics teaching anxiety; that is, teachers with mathematics anxiety are assumed to have mathematics teaching anxiety and those who experienced no mathematics teaching anxiety would not have mathematics anxiety. At the same time, the findings also challenged the other aspect of the notion. As previously reported, of the 110 participants, 46 (41.8%) reported that they experienced only mathematics anxiety, one experienced only mathematics teaching anxiety, 37 (33.6%) experienced both mathematics anxiety and mathematics teaching anxiety, and 26 (23.6%) did not experience either mathematics anxiety or mathematics teaching anxiety (see Figure 4). This result indicated that whereas 63 (57%) of the participants supported the notion that teachers with mathematics anxiety are likely to have mathematics teaching anxiety (and vice-versa), 47 (43%) of them opposed it. Brown et al.'s (2011) study with pre-service teachers found similar results: in which about 33% of the participants challenged the assumptions that mathematics anxiety would lead to mathematics teaching anxiety. Particularly from the present study, it seemed that the teachers who had mathematics teaching anxiety had mathematics anxiety; except for one participant (see Figure 4). These results indicated the difficulty with the prediction of mathematics anxiety and mathematics teaching anxiety among teachers. The results from the interview also showed that the relationship between the two constructs are not the same for all teachers as the four interviewees who in fact had varied levels of mathematics anxiety (one low, one moderate, and two high), as established through the survey, expressed that they did not have mathematics teaching anxiety. These teachers expressed that "for what we need to do we are pretty [well] prepared," indicating that they get prepared for their mathematics lessons in ways that addressed students' needs through the use of various teaching strategies. The finding also points to the importance of not employing "one size fits all" strategies as interventions to reduce elementary teachers' mathematics anxiety as some strategies and activities could be beneficial to some of them and daunting for others.

Another finding from this study was that there was no significant difference in the mathematics anxiety scores for beginning, experienced, and very experienced teachers. However, beginning teachers experienced more mathematics teaching anxiety than did the experienced and very experienced teachers. The latter finding is consistent with Hadley and Dorward's (2011) findings where participants in the first year of teaching had the highest anxiety over teaching of mathematics compared to other teachers with more years of teaching experiences. The researchers also found that teachers' mathematics teaching anxiety gradually reduces as they gain teaching experience over time and become comfortable with the curriculum. Comparatively, three of the participants who were interviewed in this study emphasised, confidently, that they taught mathematics concepts for many years and could teach the subject effectively since they were comfortable with the curriculum and were always looking for other ways to teach the concepts to promote students' understanding and reduce their anxieties for mathematics. This confession was made despite the differences in the level of mathematics anxiety that the participants experienced. Previous research by Gresham (2009) and Swars et al. (2006) reported similar findings in their study with pre-service teachers, where the participants, irrespective of their level of mathematics anxiety, indicated that they believed they could teach mathematics effectively to their students.

Findings from the interviews. The discussion of findings with respect to the last research question- *What are the self-reported causes of mathematics anxiety among elementary school teachers and what strategies did they use to cope with, diminish, or overcome it* - is presented in the following text.

The findings from the interviews that some of the participants had developed mathematics anxiety through past negative classroom experiences with teachers is consistent with the findings from previous studies (Arem, 2003; Bekdemir, 2010; Brady & Bowd, 2005; Jackson & Leffingwell, 1999; McAnallen, 2010; Perry, 2004; Shields, 2006; Tobias, 1998). Specifically, the participants attributed the causes of mathematics anxiety to their teachers' actions, insensitive comments, mean behavior, as well as their own lack of understanding of mathematics concepts. Teachers' actions, such as fast-paced instruction, lack of review on the past mathematics concepts, and teaching to the strong mathematics students in the class while others were left behind, contributed to the development of mathematics anxiety. In Brady and Bowd's (2005) study, fast paced instruction and feelings of inadequacy experienced through the teachers were reported by pre-service teachers with high levels of mathematics anxiety. Jackson and Leffingwell (1999) also reported hostile behaviour, insensitive and uncaring attitude of teachers as among those that produced or increased the mathematics anxiety experienced by college students. Perry (2004) found insensitive mathematics teachers as the cause of mathematics anxiety experienced among college students.

For the male interviewee in this study, gaps in mathematics knowledge that were due to his poor preparation before mathematics class, leading to mathematics anxiety supported findings from other studies (Arem, 2003; Sheilds, 2006). As well, mathematics anxiety resulting from participants' lack of understanding of mathematics concepts is consistent with findings from other studies (McAnallen, 2010; Meyer, 1980). In McAnallen's (2010) study, lack of conceptual mathematical knowledge combined with rote-memorization, teacher's fast-paced instruction, and feelings of humiliation experienced as a student of mathematics, were some of the reasons behind elementary school teachers' mathematics anxiety.

In addition, differences were found between the male participant's experience of mathematics anxiety and the females' experiences. The male participant did not attribute the cause of his anxiety to any socializers but himself whereas the females mentioned teachers as responsible. Apart from this, the causes of mathematics anxiety were notably different between the White teachers and their Asian counterpart due to cultural differences in what teachers can say and do in different countries. However, regardless of their gender and race/ethnicity, all four interview participants acknowledged that teachers had a great impact on helping them to overcome or cope with their anxiety about mathematics. The latter finding is consistent with researchers who suggested that teachers are key elements to reducing students' mathematics anxiety (Arem, 2003; Giest, 2010; Perry, 2004; Scarpello, 2007; Sheilds, 2006). Other ways by which some of the participants reduced or coped with mathematics anxiety as teachers include, adequate preparation before beginning mathematics lessons, reading resources that are mathematics-related, participation in workshops, and seeking assistance from other teachers and principals.

Another finding from the interviews was that the experience of mathematics anxiety affected the participants both personally and professionally. Supporting other research findings by Scarpello (2007), Vinson (2001), and Zettle and Raines (2002), the personal effects of mathematics anxiety on some of the participants at a younger age include lack of confidence in doing mathematics, lack of courage to express their feelings about mathematics to their teachers, and negative attitude towards mathematics. Avoidance of mathematics courses and mathematics-related careers were also reported by some of them which have been proclaimed by some researchers (Arem, 2003; Bursal & Paznokas, 2006; Tobias, 1998) as one of the consequences of mathematics anxiety among students. However, the experience of mathematics anxiety in the early stage of the participants' formal education seemed to have influenced their motivation to help their students who struggled with mathematics. According to Fuson (2007), while for some a certain amount of mathematics anxiety could be exciting and motivational, it could be debilitating for many others. In this study, it appeared that the participants were cognizant of "their source of mathematics anxiety [prompting them to] seek ways to provide students with a different mathematics environment" (Bush, 1989, p. 508). Thus, the experience of mathematics anxiety seemed to be debilitating for some of the participants when they were students and partly enabling them when they became teachers. It should be noted that these participants were very experienced (with over 15 years of teaching experience), with varied levels of mathematics anxiety and they reported no mathematics teaching anxiety. They indicated that they used alternative teaching methods rather than the traditional, teacher-centered method. In Chavez and Widmer's (1982) study, elementary teachers who were anxious about mathematics stated that they utilized teaching strategies, such as the use of manipulatives, games, and integration of mathematics with other subjects, which could help alleviate mathematics anxiety in their students. The teachers' unpleasant experiences with mathematics that they carried from their student life, lead them to use some of these strategies and they seemed to have the determination to break the cycle of negative attitude perpetuating itself in the students' negative attitude. Chavez and Wilder further explained that "although we cannot conclude that all math-anxious teachers are equally determined to break this cycle, it is encouraging to know that some of them are" (p. 388). This finding is supported by Hadley and Dorward's (2011) findings that for some teachers the experience of mathematics anxiety "may spur them to take action to improve their mathematics instructional practices" (p. 39) and that those who did not have mathematics teaching anxiety tended to use the non-traditional teaching practices in mathematics classes. However, it should be noted that one of the participants stated that she was not capable of teaching mathematics at the higher elementary grades. Teachers who feel this way should not be forced to teach higher grades as they could get frustrated while teaching and may not look for creative ways to promote students' understanding of mathematics concepts.

Implication for Practice/Recommendations

The study showed that in-service elementary school teachers experienced different levels of mathematics anxiety. This finding emphasized the need to eradicate, or at least reduce, mathematics anxiety among in-service elementary school teachers so that the cyclical nature and consequences of mathematics anxiety would be broken. First and foremost, elementary in-service teachers need to acknowledge their anxiety for mathematics and take charge of their mathematics learning. Tobias (1998) suggested that for individuals to overcome mathematics anxiety, they need to "take some initiative in [their] learning process" (p. 226). Frequent discussions about mathematics are recommended as helpful, specifically for women, to prevail over their fear and negative feelings about mathematics. Arem (2003) suggested positive self-talk and journal writing about the past and everyday experiences of mathematics as progressive means of handling mathematics anxiety. Positive self-talk is beneficial for improving teacher's attitude towards mathematics since negative inner dialogue maintains negative experiences of the past and escalates mathematics anxiety level. Studies have shown that elementary school teachers with positive attitude towards mathematics use teaching methods that promote students' initiatives, mathematical reasoning, and independence (Karp, 1991). On the other hand, writing a journal is effective in bringing more awareness to individuals' feelings about mathematics and could give clues as to the best steps to take in dealing with mathematics anxiety (Arem, 2003). In-service elementary school teachers should let their minds dwell on past positive experiences and successes in mathematics as this could be a source of inspiration for them and could help in the mathematics anxiety-reduction/eradication process (Perry, 2004).

In dealing with their mathematics anxiety, teachers could use manipulatives to elucidate specific numerical and geometrical connections; read about the history of mathematics to understand the theory behind what they have learnt in the past (Tobias, 1998) and what they are teaching the students; and seek additional help from their colleagues and principals. In addition, they need to resist intimidation due to lack of confidence and discard false beliefs about mathematics, such as "only the genius can learn and do mathematics", "mathematics problems must be solved quickly," and "there is only one way to get the solution to a mathematics problem." One way to achieve changes in those false beliefs is through the reading of magazines and articles relating to mathematics, where teachers would learn more about the myths regarding mathematics and realise that even the mathematicians take their time to tackle mathematics problems as they sketch them, ask themselves questions, think of examples that would demonstrate the problem, and unhurriedly go through each part of the problems for solutions. It is only when elementary school teachers recognise that they have mathematics anxiety, know its cause, and are motivated to find help to reduce it, that they can help students build confidence in mathematics and promote positive attitude towards mathematics (Smith, 2004).

Mathematics is a compulsory subject that is required to be taught by all elementary school teachers. Therefore, implementing changes to the teachers' practices and professional development are critical. School boards have a vital role to play by investigating the status of mathematics anxiety in their schools. Teachers and students could be asked through surveys about their feelings about mathematics and if they experience mathematics anxiety. All elementary in-service teachers need to be more informed about the causes, damaging consequences, and preventive measures of mathematics anxiety. School boards should provide such information through reading materials, videos clips on mathematics anxiety, and effective workshops and conferences that would target specific mathematics strands for in-service elementary teachers. Mathematics educators and researchers in the field of mathematics education could be invited to professional development days to deliver in-depth lessons on different ways to teach specific mathematics concepts (such as fractions) using different strategies, that would show teachers how to engage students with different levels of abilities in mathematics, create a conducive, inviting, and reassuring classroom climate for all students, and accommodate differing students' learning styles. This would broaden teachers' conceptual understanding of mathematics, which, in turn could reduce their mathematics anxiety and in turn their students' anxiety, as they would be able to teach the subject more effectively. As cautioned by Steel (2001), without a depth of conceptual knowledge of mathematics, it would be problematic for teachers to provide students with rich mathematics questions that they need to acquire meaningful understanding of mathematics. Thus, professional development programs for elementary in-service teachers should take into account their differential mathematics preparation and background. Additionally, teachers who have overcome their anxieties for mathematics could be invited during formal and informal meetings to share their experiences on how they got rid of their feelings of mathematics anxiety.

Parental encouragement in, attitude toward, behaviour related to, and value for mathematics could affect students' fondness of, interest in, and feelings about mathematics, positively or negatively. Also, there is the possibility that parental attitudes and perceptions could have an impact on students' levels of mathematics anxiety (Jameson, 2014). Therefore, individual schools within the boards of education should establish mathematics events that would involve parents where the importance of their contribution to their children's successes in mathematics would be emphasised. Extra support for parents who struggle with mathematics should also be offered by the schools. An example of such support is offered by the Peel District School Board, Ontario through the establishment of parenting centres in some of their schools. Parents are encouraged to visit the schools and participate in mathematics activities, which in turn could enhance their understanding of mathematics.

One of the findings in this study was that some teachers seemed to be more willing to explore various avenues to improve their knowledge of mathematics than others. As previously explained, approximately 61% of the participants had studied mathematics as far as grade 12, while 39% had studied the subject at the post-secondary level. Past research has shown that many college and university students who are anxious about mathematics choose to become elementary school teachers to avoid further mathematics requirements at colleges and universities (Arem, 2003; Tobias, 1998). Teachers who are reluctant to broaden their mathematical knowledge, perhaps due to their anxiety and fear of mathematics, may not be interested to learn about alternative teaching methods that could help students learn mathematics. These teachers tend to use traditional teaching methods and the same lessons plans that they have developed over time. The alternative teaching methods, which include the use technology, manipulatives and pictorial representations, mathematics-related games, real-life applications, and collaborative and cooperative learning groups, provide numerous teaching techniques to differentiate learning for students with diverse learning styles and can reduce mathematics anxiety (Hembree, 1990; Gresham 2007a; Tobias, 1998). This problem could be addressed by the school boards through the implementation of an on-going program that would allow selected elementary school teachers, perhaps those who might have been identified as possessing some level of mathematics anxiety through the survey administered by the board, to attend effective mathematics courses at the university. These courses could be organized during the summer break, such that at the end of the course the attendee teachers would share their understandings of various mathematics concepts (including materials and activities) that they learned, with their colleagues at schools. Also, a website that would be easily accessible to teachers could be purposely created with these materials and activities, so that those who suffer from mathematics anxiety could refer to it for better understanding of mathematics concepts and materials that they teach.

This study also has implications for the teacher education program. Although the study was conducted with elementary school in-service teachers, reducing mathematics anxiety and mathematics teaching anxiety among pre-service teachers, who would later become “beginning” classroom teachers, would benefit them and their future students. This study showed that, although beginning and experienced teachers have levels (low, moderate, high) of mathematics anxiety, beginning teachers’ mathematics teaching anxiety is higher than in the experienced teachers. Teacher educators need to be aware of pre-service teachers who have anxiety about mathematics and teaching of mathematics. The RMARS instrument, together with a short questionnaire that contains questions regarding mathematics teaching anxiety, could be administered in the first day of mathematics courses to detect pre-service teachers who may have anxiety over mathematics and the teaching of mathematics so that adequate help could be provided for them to reduce their anxieties.

Previous studies (Bursal & Paznokas, 2006; Hembree, 1990; Gresham, 2007a; Sloan, 2010; Vinson, 2001) have shown that mathematics anxiety levels could be reduced among pre-service teachers with an emphasis on understanding mathematics through the use of manipulatives, writing journal logs, and classroom discussions. In particular, the use of manipulatives not only reduces mathematics anxiety levels but also gives better understanding of the concepts, improves confidence levels of the learners, and produces positive attitudes toward mathematics (Sloan, 2010). Therefore, teacher educators, through discussions about the causes and consequences of mathematics anxiety and the use of many different teaching strategies and activities, could help pre-service teachers develop a deeper understanding of mathematics concepts and also reduce mathematics anxiety and mathematics teaching anxiety. Brown et al. (2011) cautioned on the specific outcomes of some of the strategies that could be used to reduce mathematics anxiety and mathematics teaching anxiety among pre-service teachers. For example, the researchers stated that pre-service teachers might view educational movies differently, as those with mathematics anxiety and mathematics teaching anxiety would concentrate more on students' development of concepts, while those with only mathematics teaching anxiety would concentrate on teachers' practices. Strategies that would be used with pre-service teachers should address many aspects of mathematics anxiety and mathematics teaching anxiety that they may experience and should encourage the use of manipulatives, mathematics-related games, as well as individual and group projects, and technology. Discussions around positive and negative experiences, and successful and unsuccessful strategies that they had employed in mathematics classrooms, during their practicum, should be shared among the students, after their placements, for reinforcement on ways to deal with mathematics anxiety and mathematics teaching anxiety that they might have experienced during their field placements.

Implication for Theory

In this study, findings from the interviews with teachers supported ideas of Vygotsky's (1981) socio-cultural theory, as social interaction between some of the participants and their past teachers seem to have led to the development of mathematics anxiety. Negative experiences that developed, through these interactions, into mathematics anxiety led to loss of confidence, gaps in mathematical knowledge, and avoidance of mathematics. Some of the participants could not comprehend mathematics at some points in their education because they had gaps in mathematics knowledge that was not addressed by their teachers. Thus, they could be considered to have lacked the requisite social interaction at some point in their mathematical learning process. At the same time, participants' parents, perhaps due to low SES, did not provide mathematics-related activities, outside the school, that could give participants more understanding of the mathematics that they missed out in the classroom. The feeling of mathematics anxiety affected the participants' process of learning as they could not "connect the dots" in the concepts they were being taught; it impacted their interactions with teachers as they could not ask for explanation on the concepts that they found difficult to understand; and it influenced their interaction with friends as they gravitated towards students that were not considered good in mathematics. In essence, it may be inferred that, when students develop mathematics anxiety, as in the case of this study participants when they were young, it affects the social interactions between the students and teachers, whose responsibility it is to help students develop mathematical understanding and move them beyond their current level of abilities in the course of social interaction. As noted by Vygotsky (1978), teachers or more capable peers with higher aptitude could help individuals learn within the "zone of proximal development" (ZPD); a place where learning occurs in such a way that individuals are assisted to move from their current/actual understanding to their potential understanding. According to Vygotsky, the teacher should be aware of the individual variability in the ZPD of a student who is learning and growing in their knowledge or confidence with a given topic or skill. For students who do not have teachers who believe in them and who may not have support at home, there is a danger that they may avoid peers who are advanced and who could help them to overcome the present hurdles in mathematics. Overall, it appeared that some of the participants who took part in the interview, lacked adequate social interaction with teachers, parents, and perhaps peers in early stage of their learning of mathematics.

The findings from this study supported the dynamic interplay of environmental, personal, and behavioural factors described by Bandura's social cognitive theory. For instance, it appeared that for some of the participants, teachers' (environmental factor) teaching strategies, insensitive comment, and mean behaviour led to low confidence in their mathematics abilities and poor performance (personal factor). Specifically for one of the participants, a low confidence level in mathematics abilities resulted in avoidance of mathematics and mathematics-related careers (behavioural factor). Avoidance of mathematics by some participants lead to gaps in their mathematical understandings and poor performance, which in turn might have reinforced teachers' lack of encouragement as the participants experienced mathematics anxiety (see Figure 7). Two of the participants stated that they chose their friends in the mathematics classroom due to their perceived mathematics abilities and beliefs. This is consistent with Bandura's statement that "what people think, believe, and feel affects how they behave" (Bandura, 1986, p. 25). The participants’ beliefs about their capacity to learn mathematics drew them towards peers that they felt had similar aptitude as them during their schooling.

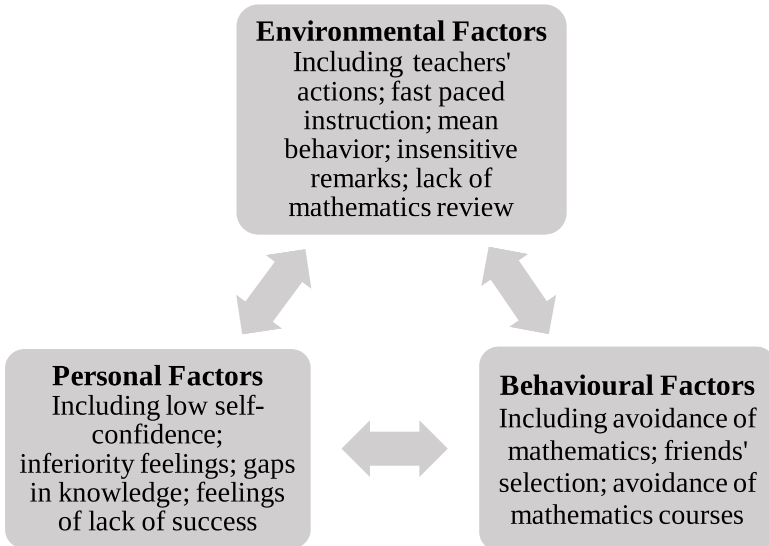

Figure 7. Interplay of Bandura’s (1989) three reciprocal factors related to mathematics anxiety with participants as students

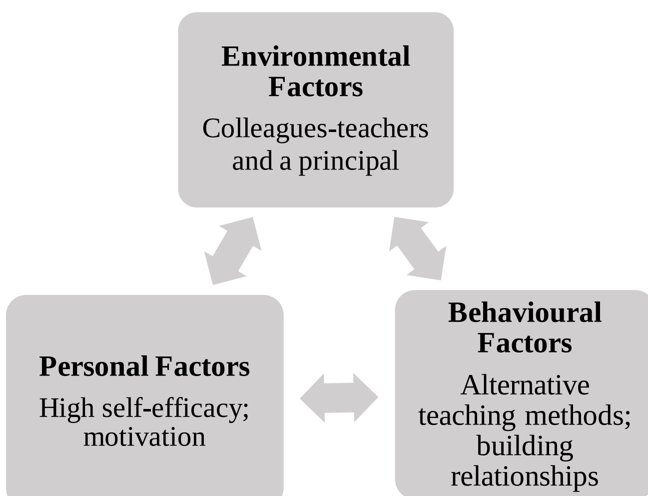

Figure 8. Interplay of Bandura’s (1989) three reciprocal factors related to mathematics anxiety with participants as teachers

The findings from this study reiterate the fact that teachers must be mindful of what they say and do with their students in mathematics classrooms as their actions could cause or have an influence on the development of mathematics anxiety among their students. Bandura's (1986) theory suggests that teachers could help students to improve their emotional states, correct their negative self-beliefs and ways of thinking, make changes to the school and classroom environments that may hinder their successes and enhance their academic skills, including skills in mathematics (Pajares, 2002). By so doing, teachers could help students improve within the ZPD and bridge the gap between present and potential understanding of mathematics concepts.

This study extends the current literature by using Vygotsky (1981) and Bandura (1986) theories, which complement each other, to give a holistic presentation of elementary teachers' mathematics anxiety experiences. It provides insights on the interplay of the three factors (that is, personal, behavioural, and environmental as defined by Badura) with respect to teachers as the environmental factor that influenced the development of participants' mathematics anxiety. Using the theories of Vygotsky and Bandura, one could suggest that some elementary teachers who experience high levels of mathematics anxiety may find it difficult to provide the guidance that the students need within their ZPD and that they may also have low self-efficacy in teaching the subject effectively to their students. On the other hand, one finding from this study suggest that the very experienced teachers, regardless of their levels of mathematics anxiety could possess high self-efficacy beliefs about their abilities to teach mathematics effectively. As previously stated, experience of mathematics anxiety served as self- motivational for very experienced teachers who appeared to be cognizant of and used alternative teaching methods, paying attention to students' needs in the mathematics learning, and building relationships with students, colleagues/principal, and parents (see Figure 8). They also used humour during teaching and exhibited caring attitude towards their students.

Social cognitive theory proposed that other factors, such as socioeconomic status, educational and familial structures, indirectly affect human behavior to the level that they have an influence on individual's aspirations, self-efficacy beliefs, personal standards, and emotional states (Pajares, 2002). More research is needed with other environmental factors, such as parents, to see how their influences on the development of mathematics anxiety play out with the other two determinant factors - personal and behavioural.

Limitations of the Study

The study represents the perspectives of a group of in-service elementary school teachers; therefore, the findings of the study are not generalizable beyond the participants in the study. Although many attempts were made to collect data from elementary in-service teachers in this study, only 15% of them completed the online survey. In addition, the researcher intended to obtain an equal number of male participants and female participants for the qualitative part of the study, but this became impossible as selected participants did not respond to the repeated invitations to participate in the interviews. For this reason, one male and three female teachers were interviewed to explore their experiences with mathematics anxiety and mathematics teaching anxiety. Four interview participants is a very small group, but the focused questions and the rich data collected mitigate this weakness.

Interviews involving teachers, perhaps with equal number of male and female participants from various cultural backgrounds, would provide more room for comparison and better understanding of teachers' mathematics anxiety and mathematics teaching anxiety. Especially, getting to know more about the attitudes and practices of in-service elementary school teachers who do not experience mathematics teaching anxiety may likely help in identifying interventions which could help to reduce mathematics teaching anxiety in other teachers who may suffer from it.

Another limitation of the study was that the four teachers that were recruited for the interview were very experienced, with each having over 15 years of teaching experience. Although they were from different schools and boards, and with diverse perspectives, they were unlikely to be representative of the elementary teachers as they had experienced several reforms of mathematics curricula, compared to the beginning teachers. Future studies should consider interviews with elementary school teachers with different levels of teaching experiences, which may provide insights for creating focussed professional development in mathematics or perhaps mentoring programs for elementary school teachers. Also, the principals' perspectives on mathematics anxiety should be investigated since they play a crucial role in the professional development of elementary school teachers and their students.

Suggestions for Future Research

This study was inspired by the observed limited research in the literature that addressed mathematics anxiety and mathematics teaching anxiety among in-service elementary school teachers. Thus, more Canadian-based research is needed to explore the development of mathematics anxiety and mathematics teaching anxiety in in-service elementary school teachers and their effects on their practices as professionals. Such research would not only add to the literature, but also help teachers be more aware of their own anxieties for mathematics and its consequences on their students.

A cross-cultural research on mathematics anxiety involving elementary school teachers from different countries may offer more insights on factors that contribute to mathematics anxiety, particularly those that are related to cultural and societal influences. Such a research should also consider the multi-dimensionality of mathematics anxiety as some groups of participants may experience mathematics test anxiety while others may have numerical task anxiety or mathematics course anxiety.

Researchers (Brown et al., 2011; Levine, 1993; Peker, 2009) have stated that little is known about mathematics teaching anxiety among pre-service teachers and I would add that the same applies to in-service teachers. More research is needed in the area of mathematics teaching anxiety. The translated MATAS instrument (MATAS-E) should be tested on samples similar to the one used in this study to verify its validity and reliability. Other studies should consider creating reliable and valid instruments, specific to ethnic groups, to get a better picture of the causes and effect of mathematics teaching anxiety among teachers.

Studies should also be conducted to examine the relationship between teacher's level of mathematics anxiety and their students' levels of mathematics anxiety to determine whether the two influence one another.

Conclusion

In-service elementary school teachers play a major role in the learning of mathematics by students. When these teachers are anxious about mathematics and lack understanding of mathematics concepts, they are likely to engage in mathematics avoidance behaviours and may not be able to guide students into deeper understanding of the subject. Also, their anxiety for mathematics may rub off on their students, leading to hindrances that may prevent students from becoming successful mathematics learners. The problem of mathematics anxiety among students and teachers does not have a simple solution. Efforts to reduce or eliminate mathematics anxiety among in-service teachers and their students should involve teachers, their school boards, and teacher educators and researchers. All these categories of people should work together to support teachers by providing programs and workshops that would enhance teachers' understanding of mathematics concepts, encourage best teaching practices and behaviours, as well as promote positive attitude towards mathematics. Aside from this, teachers and parents should be cognisant of gender bias pertaining to mathematics in school and home settings and work together to combat it. They need to examine and address any stereotype that they may uphold in relation to mathematics since such false beliefs may be responsible for their differential treatments and interactions with students. It is equally important that teachers acknowledge their fears, anxieties, and difficulties with mathematics, create a plan to get rid of them, and ask for assistance when they need it. A great mathematics teacher can make a huge difference on students' feelings about mathematics and how much mathematics knowledge they acquire in the classroom. Addressing mathematics anxiety among teachers would help increase students' achievement in mathematics and may also increase their participation in mathematics-related careers.

REFERENCES

Adeyemi, A. Y. (2010). *Factors impacting female's decision to pursue mathematics-related careers: A case study approach* (Master's thesis). Retrieved from ProQuest Dissertations & Theses Global. (Order No. MR62737)

Alphonso, C., & Morrow, A. (2013, August 28). Ontario teachers need better math training, minister says, *The Globe and Mail*, Retrieved from http://www.theglobeandmail.com/news/national/education/ontario-testing-shows-dip-in-student-math-skills-for-fifth-year-in-a-row/article13996303/

Altermatt, E., & Kim, M. (2004). Can anxiety explain sex differences in college entrance exams scores? *Journal of College Admission*, *183*, 6–11.

Alexander, L., & Martray, C. R. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale, *Measurement and Evaluation in Counseling and Development*, *22*(3), 143–150.

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

Ashcraft, M., & Kirk, E. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*(2), 224–237.

Ashcraft, M. H., & Krause, J. K. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, *14*(2), 243–248.

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psycho educational Assessment*, *27*(3), 197–205.

Ashcraft, M., & Ridley, K. (2005). Math anxiety and its cognitive consequences: A tutorial review. In J. I. Campbell (Ed.), *Handbook of mathematical Cognition* (pp. 315–326). New York, NY: Psychology Press.

Avvisati, F. (2012, February). *PISA 2012: Evaluating school systems to improve education*. Paper presentation at the meeting of 7th Annual Ontario Education Research Symposium (OERS), Toronto, ON.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American Educator*, *29*(3), 14–46.

Balogˇlu, M., & Koçak, R. (2006). A multivariate investigation of the differences in mathematics anxiety. *Personality & Individual Differences*, *40*(7), 1325–1335.

Baloğlu, M., & Zelhart, P. F. (2007). Psychometric properties of the revised mathematics anxiety rating scale. *Psychological Record*, *57*(4), 593–611.

Bandalos, D. L., Yates, K., & Thorndike-Christ T. (1995). Effects of math self-concept, perceived self-efficacy and attributions for failure and success on test anxiety. *Journal of Educational Psychology*, *87*(4), 611–623.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, *44*, 1175–1184.

Bandura, A. (1993). Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational Psychologist*, *28*(2), 117.

Bates, A. B., Latham, N., & Kim, J. (2011). Linking preservice teachers' mathematics self-efficacy and mathematics teaching efficacy to their mathematical performance. *School Science & Mathematics*, *111*(7), 325–333. doi:10.1111/j.1949-8594.2011.00095.x

Beilock, S. L., & Carr, T. H. (2005). When high-powered people fail: Working memory and "choking under pressure" in math. *Psychological Science*, *16*(2), 101–105.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(5), 1860–1863.

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics*, *75*(3), 311–328.

Berch, D. B., & Mazzocco, M. M. (2007). *Why Is Math So Hard for Some Children? The Nature and Origins of Mathematical Learning Difficulties and Disabilities*. Baltimore, MD: Brookes Publishing Company.

Bernstein, J., Relly, L., & Cote-Bonanno, J. (1992). Barriers to women entering the workforce: math anxiety. *New Jersey Equity Research Bulletin*, *3*, 3–6.

Bonk, C. J., & Kim, K. A. (1998). Extending sociocultural theory to adult learning. In M. C. Smith & T. Pourchot (Eds.), Adult learning and development: Perspective from educational psychology (pp. 67–88). Mahwah, NJ: Lawrence Erlbaum Associates.

Boyatzis, R. E. (1998) *Transforming qualitative information: Thematic analysis and code development.* Thousand Oaks, CA: Sage.

Brady, P., & Bowd, A. (2005). Mathematics anxiety, prior experience and confidence to teach mathematics among pre-service education students. *Teachers & Teaching: Theory and Practice*, *11*(1), 37–46.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa

Brown, A., Westenskow, A., & Moyer-Packenham, P. (2011). Elementary pre-service teachers. Can they experience mathematics teaching anxiety without experiencing mathematics anxiety? Retrieved from http://www.k12prep.math.ttu.edu/journal/attributes/volume.shtml

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and pre-service elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics*, *106*(4), 173–179.

Bush, W. S. (1989). Mathematics anxiety in upper elementary school teachers. *School Science and Mathematics*, *89*(6), 499–509.

Catsambis, S. (2005). The Gender Gap in Mathematics: Merely a Step Function? In A. Gallagher and J. Kaufman (Eds.), *Gender Differences in Mathematics. An Integrative Psychological Approach* (pp. 220–245) Cambridge, UK: Cambridge University Press.

Cerry, K. (2013).What is social cultural theory? Retrieved from http://psychology.about.com/od/developmentecourse/f/sociocultural-theory.htm

Chavez, A., & Widmer, C. C. (1982). Math anxiety: Elementary teachers speak for themselves. *Educational Leadership, 39*(5), 387–388.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education* (5th ed.). London, UK: Routledge.

Cooper, S. E., & Robinson, D. A. G (1991). The relationship of mathematics self-efficacy beliefs to mathematics anxiety and performance. *Measurement and Evaluation in Counseling and Development*, *24*, 4–12.

Creswell, J. W. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative approaches to research* (2nd ed.). Upper Saddle River, NJ: Merrill/Pearson Education.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Boston, MA: Pearson Education.

Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Thousand Oaks, CA: Sage.

Dunkle, S. M. (2010). *Remediation of math anxiety in preservice elementary school teachers* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3411597)

Eccles, J. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, *18*, 585–609.

Education Quality and Accountability Office (EQAO). (2001). *Ontario provincial report on achievement 2000–2001: Secondary schools* (Education Quality Accountability Office, Ontario). Retrieved from, http://www.eqao.com/pdf_e/01/01P081e.pdf

Education Quality and Accountability Office (EQAO). (2014). Ontario Student Achievement: EQAO’s Provincial Elementary School Report: Results of the 2013–2014 Assessments of Reading, Writing, and Mathematics, Primary Division (Grades 1–3) and Junior Division (Grades 4–6). Retrieved from, http://www.eqao.com/ProvincialReport/Files/14/PDF/provincial-report-elementary-2014.pdf

Ercikan, K., McCreith, T., & Lapointe, V. (2005). Factors Associated With Mathematics Achievement and Participation in Advanced Mathematics Courses: An Examination of Gender Differences From an International Perspective. *School Science & Mathematics, 105*(1), 5–14.

Ertekin, E., Dilmac, B., & Yazici, E. (2009). The relationship between mathematics anxiety and learning styles of pre-service mathematics teachers. *Social Behavior & Personality: An International Journal, 37*(9), 1187–1195.

Erktin, E., Dönmez, G., & Özel, S. (2006). Psychometric properties of a Mathematics Anxiety Scale. *Education and Science*, *31*(140), 26–33.

Ezzy, D. (2002). *Qualitative analysis. Practice and innovation*. Madison, NY: Routledge.

Fiore, G. (1999). Math-abused students: Are we prepared to teach them? *Mathematics Teacher, 92*(5), 403–406.

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education.* New York, NY: McGraw-Hill.

Furner, J., & Berman, B. (2005). Confidence in their ability to do mathematics: The need to eradicate math anxiety so our future students can successfully compete in a high-tech globally competitive world. *Dimensions in Mathematics, 18*(1), 28–31.

Fuson, J. Y. (2007). *A study of the relationship between math anxiety and select demographics* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3258361)

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. *Journal of Instructional Psychology*, *37*(1), 24–31.

Gierl, M. J., & Bisanz, J. (1995). Anxieties and attitude related to mathematics in grade 3 and 6. *Journal of Experimental Education*, *63*(2), 139–159.

Gresham, G. (2004). Mathematics anxiety in elementary students. *CMC ComMuniCator, 29*(2), 28–29.

Gresham, G. (2007a). A study of mathematic anxiety in pre-service teachers. *Early Childhood Education Journal*, *35(*2), 181–188.

Gresham, G. (2007b). An invitation into the investigation of the relationship between mathematics anxiety and learning styles in elementary pre-service teachers. *Journal of Invitational Theory and Practice*, 13, 24–33.

Gresham, G. (2009). Examining the relationship between pre-service elementary teachers' experience of mathematics anxiety and their efficacy for teaching mathematics. *Journal of Classroom Interaction*, *2*(44), 22–38.

Gunderson, A., E., Ramirez, G., Levine, C., S., & Beilock, L., S. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*, 153–166 doi: 10.1007/s11199-011-9996-2

Hadfield, O. D., & McNeil, K. (1994). The relationship between Myers-Briggs personality type and mathematics anxiety among pre-service elementary teachers. *Journal of Instructional Psychology*, *21*(4), 375–384.

Hadley, K. M., & Dorward, J. (2011). The relationship among elementary teachers' mathematics anxiety, mathematics instructional practices, and student mathematics achievement. *Journal of Curriculum and Instruction*, *5*(2), 27–44.

Haenen, Schrijnemakers, & Stufkens, (2003). Sociocultural theory and the practice of teaching historical concepts. In A. Kozulin, B. Gindis, B., V. S. Ageyev, & S. M. Miller (Eds.), *Vygotsky's educational theory in cultural context* (pp. 246–266). New York: Cambridge University Press.

Harper, N., & Daane, C. (1998). Causes and reduction of math anxiety in pre-service elementary teacher. *Action in Teacher Education*, *19*(4), 29–38.

Hart, L. C., & Swars, S. (2009). The lived experiences of elementary prospective teachers in mathematics content coursework. *International Journal of Teacher Development*, *13*(2), 159–172.

Haynes, A. F., Mullins, A. G., & Stein, B. S. (2004). Differential models for math anxiety in male and female college students. *Sociological Spectrum*, *24*(3), 295–318.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33–46.

Hill, H. C. (2010). The nature and predictors of elementary teachers' mathematical knowledge for teaching. *Journal for Research in Mathematics Education*, *41*(5), 513–545.

Hilton, A. & Skrutkowski, M. (2002). Translating instruments into other languages: Development and testing processes. *Cancer Nursing*, *25*(1), 1–7.

Ho, H., Senturk, D., Lam, A. G., Zimmer, J. M., Hong, S., Okamoto, Y., Chiu, S., Nakazawa, Y., & Peng, C. (2000). The affective and cognitive dimensions of math anxiety: A cross-national study. *Journal for Research in Mathematics Education, 31*(3), 362–379.

Hoff, D. J. (2001). Introduction to algebra: It's elementary. *Education Week, 20*(28), 1–3.

Hopko, D. R. (2003). Confirmatory factor analysis of the math anxiety rating scale – revised. *Educational and Psychological Measurement*, *63*(2), 336–351.

Huck, S.W. (2004). *Reading statistics and research* (4th ed.). Boston: Pearson Education Inc.

Ingersoll, R. M. (1999). The problem of underqualified teachers in American secondary schools, *Educational Researcher,* 28(2), 26–37.

Iossi, L. H. (2009). *The mathematics anxiety of bilingual community college students* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3380825)

Ivankova, N. V., & Stick, S. L. (2007). Students' persistence in a distributed doctoral program in educational leadership in higher education: a mixed methods study. *Research in Higher Education*, *48*(1), 93–135. doi:10.1007/s11162-006-9025-4

Jackson, C., & Leffingwell, R. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher*, *92*(7), 583–587.

Jameson, M. M. (2010). Math anxiety: Theoretical perspectives on potential influences and outcomes. In J. Cassady (Ed.), *Anxiety in schools: The causes, consequences, and solutions for academic anxieties* (pp. 45–55). New York, NY: Peter Lang.

Jameson, M. M. (2014). Contextual factors related to math anxiety in second-grade children. *The Journal of Experimental Education*, *82*(4), 518–536. doi:10.1080/00220973.2013.813367

Jane, B., & Robbins, J. (2007). Intergenerational learning: grandparents teaching everyday concepts in science and technology. *Asia-Pacific Forum on Science Learning and Teaching*, *8*(1). Retrieved from http://www.ied.edu.hk/apfslt/v8_issue1/jane/index.htm#abstract

Johns, M., Schmader, T., & Martens, A. (2005). Knowing is half the battle: Teaching stereotype threat as a means of improving women's math performance. *Psychological Science*, *16*, 175‒179.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14‒26.

Kajander, A. (2010). Mathematics teacher preparation in era of curriculum change: The development of mathematics for teaching. *Canadian Journal of Education*, *33*(1), 228‒255.

Kajander, A., Kotsopoulos, D., Martinovic, D., & Whiteley, W. (2012). Mathematics pre-service teacher education in Ontario: Consultation brief regarding the proposed extended pre-service teacher education program. Contribution of the Sub-Committee of the Mathematics Education Forum of the Fields Institute for Research in Mathematical Sciences, Toronto, ON. Retrieved from http://fmej.fields.utoronto.ca/index.php/FMEJ/article/view/81/41

Karp, K. S. (1991). Elementary school teachers' attitudes toward mathematics: The impact on students' autonomous learning skills. *School Science and Mathematics*, *91*(1), 265‒270.

Kazelskis, R., Reeves, C., Kersh, M. E., Bailey, G., Cole, K., Larmon, M., Hall, L., & Holliday, D. C. (2000). Mathematics anxiety and test anxiety: Separate constructs? *The Journal of Experimental Education*, *68*(2), 137–146.

Khatoon, T., & Mahmood, S. (2010). Mathematics anxiety among secondary school students in India and its relationship to achievement in mathematics. *European Journal of Social Sciences*, *16*(1), 75–83.

Kraut, R., Olson, J., Banaji, M., Bruckman, A., Cohen, J., & Couper, M. (2004). Psychological research online: Report of board of scientific affairs' advisory group on the conduct of research on the internet. *American Psychologist*, *59*, 105–117.

Kulpa, C. S. (2007). *Algebra and the elementary school: Teacher math anxiety and its impact on student achievement* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3273908)

Levine, G. (1993). Prior mathematics history, anticipated mathematics teaching style, and anxiety for teaching mathematics among pre-service elementary school teachers. Proceeding of the Fifteenth Annual Meeting of the North American chapter of the International Groups for the Psychology of Mathematics Education, USA, 2, 26.

Levine, G. (1996). Closing the gender gap: Focus on mathematics anxiety. *Contemporary Education*, *57*(1), 42–45.

Lincoln,Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Thousand Oaks, CA: Sage

Liu, F. (2008). Impact of online discussion on elementary teacher candidates' anxiety towards teaching mathematics. *Education*, *128*(4), 614–629.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Ma, X. (1999). A meta-analysis of the relationship between anxiety towards mathematics and achievement. *Journal for Research in Mathematics Education*, *30*(5), 520.

Ma, X., & Cartwright, F. (2003). A longitudinal analysis of gender differences in affective outcomes in mathematics during middle and high school. *School Effectiveness and School Improvement*, *14*(4), 413–439.

Maneesriwongul, W., & Dixon, J. K. (2004). Instrument translation process: a methods review. *Journal of Advanced Nursing*, *48*(2), 175–186. doi:10.1111/j.1365-2648.2004.03185.x

Maxwell, J. (2005). *Qualitative research design: An interactive approach* (2nd ed.). Thousand Oaks, CA: Sage.

McAnallen, R. R. (2010). *Examining mathematics anxiety in elementary classroom teachers* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3464333)

Merritt, W. P. (2011). *Exploring math anxiety as it relates to math achievement, gender, and race* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3487164)

Meyer, R. A. (1980). *Attitudes of elementary teachers toward mathematics*. (ERIC Document Reproduction Service No. ED 190 388)

McCoy, L. P. (1992). Correlates of mathematics anxiety. *Focus on Learning Problems in Mathematics*, *14*(2), 51–57.

Miqdadi, R. (2006). *Mathematics anxiety: A cross-cultural study of jordan and the united states* (Doctoral Dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3215029)

Mulenga, C. B. (1990). A synthesis of correlational findings on college mathematics anxiety. Unpublished doctoral dissertation, Ohio State University.

Muller, C. (1998). Gender differences in parental involvement and adolescents' mathematics achievement. *Sociology of Education, 71*(4), 256–336.

Nardi, P. (2006). *Doing survey research: A guide to quantitative methods* (2nd ed.) Boston, MA: Pearson Education.

Onwuegbuzie, A. J. (1998). Statistics anxiety: A function of learning style? *Research in Schools, 5*(1), 43–52.

Onwuegbuzie, A. J., & Teddlie, C. (2003). A framework for analysing data in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), Handbook of mixed methods in social & behavioural research (pp. 351–383). Thousand Oaks, CA: Sage.

Osborne, J.W. (2001). Testing stereotype threat: does anxiety explain race and sex differences in achievement? *Contemporary Educational Psychology 26*, 291–310. doi:10.1006/ceps.2000.1052

Otrar, M. (2006). The validity and reliability of the Marmara Learning Styles Scale. Educational *Sciences: Theory and Practice*, 7(3), 1379–1419.

Pajares, F. (2002). *Overview of social cognitive theory and of self-efficacy*. Retrieved from http://www.emory.edu/EDUCATION/mfp/eff.html

Pajares, F., & Miller, D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, *86*, 193–203.

Pallant, J. (2005). *SPSS survival manual: A step to step guide to data analysis using SPSS for Windows (version 12*, 2nd ed.). New York, NY: Open University Press.

Panofsky, C. P., John-Steiner, V., & Blackwell, P. J. (1990). The Development of Scientific Concepts and Discourse. In L. C. Moll (Ed.) *Vygotsky and Education: Instructional implications of sociohistorical psychology* (pp. 251–267). NY: Cambridge University Press.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage.

Peker, M. (2006). Development of the mathematics teaching anxiety scale. *Educational Sciences and Application*, *9*, 73–92.

Peker, M. (2009). Pre-Service teachers' teaching anxiety about mathematics and their learning styles. *Eurasia Journal of Mathematics, Science & Technology Education*, *5*(4), 335–345.

Perry, A. B. (2004). Decreasing math anxiety in college students. *College Student Journal, 38*(2), 321–324.

Popham, W. J. (2008). Timed tests for tykes? *Educational Leadership, 65*(8), 86–87.

Reips, U. D. (2002). Standards for Internet-based experimenting. *Experimental Psychology, 49*, 243–256.

Richardson, F., & Suinn, R. (1972). The mathematics anxiety rating scale: Psychometric date. *Journal of Counseling Psychology*, *19*(6), 551–554.

Rounds, J. B., & Hendel, D. D. (1980). Measurement and dimensionality of math anxiety. *Journal of Counseling Psychology*, *27*(2), 138–149.

Rubin, H. J., & Rubin, I. S. (2005). *Qualitative interviewing: The art of hearing data* (2nd ed.) Thousand Oaks, NY: Sage.

Satake, E., & Amato, P. P. (1995). Mathematics anxiety and achievement among Japanese elementary school students. *Educational and Psychological Measurement, 55*, 1000–1007.

Scarpello, G. (2007). Helping students get past math anxiety. *Techniques: Connecting Education & Careers, 82*(6), 34–35.

Shields, D. J. (2006). *Causes of math anxiety: The student perspective* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3206656)

Sherman, H. J., Richardson, L. I., & Yard, G. J. (2009). Teaching learners who struggle with mathematics. New Jersey: Pearson Education.

Sloan, T. (2010). A quantitative and qualitative study of math anxiety among pre-service teachers. *The Educational Forum*, *74* (3), 242–256.

Sloan, T., Daane, C. J., & Giesen, J. (2002). Mathematics anxiety and learning styles: What is the relationship in elementary pre-service teachers? *School Science & Mathematics, 102*(2), 84–87.

Smith, M. R. (2004). Math anxiety: causes, effects, and preventative measures. Retrieved from http://digitalcommons.liberty.edu/honors/255/

Spielberger, C. D. (1977). *The Test Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Standing, L. G. (2006). Why Johnny still can't add: Predictors of university student performance on an elementary arithmetic test. *Social Behavior and Personality*, *34*(2), 151–160.

Steele, D. F. (2001).Using Sociocultural Theory to Teach Mathematics: A Vygotskian Perspective. *School Science & Mathematics*, *101*(8), 404–416.

Stuart, V. (2000). Math curse or math anxiety? *Teaching Children Mathematics*, *6*(5), 330–336.

Swars, S., Daane, C., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary pre-service teachers? *School Science and Mathematics*, *106*(7), 306–315.

Tapia, M., & Marsh, G. E., II. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, *2*(8), 16–21.

Tashakkori, A., & Creswell, J. W. (2007). The new era of mixed methods. *Journal of Mixed Methods Research*, *1*(1), 3–7.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches*. Thousand Oaks, CA: Sage.

Teddlie, C., & Tashakkori, A. (2009). *Foundation of mixed methods research. Integrating quantitative and qualitative approaches in social and behaviour sciences*. Thousand Oaks, CA: Sage.

The Teacher Education Application Service (TEAS). (2012). Instruction Booklet. Retrieved from http://www.ouac.on.ca/teas

Tiedemann, J. (2000). Parents' gender stereotypes and teachers' beliefs as predictors of children's concept of their mathematical ability in elementary school. *Journal of Educational Psychology*, *92*(1), 144–151.

Tiedemann, J. (2002). Teachers' gender stereotypes as determinants of teacher perceptions in elementary school mathematics. *Educational Studies in Mathematics*, *50*(1), 49–62.

Tobias, S. (1978). *Overcoming math anxiety*. New York, NY: W. W. Norton Co, Inc.

Tobias, S. (1998). Anxiety and mathematics. *Harvard Education Review*, 50, 63–70.

Vinson, B. (2001). A comparison of pre-service teacher's mathematics anxiety before and after a methods class emphasizing manipulative. *Early Childhood Education Journal*, *29*(2), 89–94.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1978). Interaction between learning and development. In Cole, M., John-Steiner, V., Scribner, S., & Souberman, E. (Eds.), *Mind in Society. The Development of Higher Psychological Processes* (pp.79–91). Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987). Thinking and Speech. In R.W. Rieber & A. S. Carton (Eds.), *The Collected Works of L.S. Vygotsky, Vol. 1, Problems of general psychology* (N. Minick, Trans.) (pp. 39–285). NY: Plenum Press.

Vygotsky, L. S. (1981). The genesis of higher mental functions. In Wertsch, J. V. (Ed.), *The concept of activity in Soviet psychology* (pp. 144–188). NY: M.E. Sharpe.

Vygotsky, L. S. (1994). The development of academic concept in school aged children. In R. Vander Veer, & J. Valsiner (Eds), *The Vygotsky reader* (pp. 355–370). Oxford, UK: Blackwell.

Weeks, A., Swerissen, H., & Belfrage, J. (2007). Issues, challenges, and solutions in translating study instruments. *Evaluation Review*, *31*(2), 153–165.

Wieschenberg, A. A. (1994). Overcoming conditioned helplessness in mathematics. *College Teaching*, *42*(2), 51.

Wigfield, A., & Meece, J. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology*, *80*(2), 210–216.

Wilder, S. (2012). *Gender differences in factors pertaining to math anxiety among college students* (Doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (Order No. 3510769)

Williams, W. V. (1988). Answers to questions about math anxiety. *School Science and Mathematics 88*(2), 95–104.

Woodard, T. (2004). The effects of math anxiety on post-secondary developmental students as related to achievement, gender, and age. *Inquiry*, *9*(1). Retrieved from http://www.vccaedu.org/inquiry/inquiry-spring 2004/i -91-woodard.html

Yazici, E., & Ertekin, E. (2010). Gender differences of elementary prospective teachers in mathematical beliefs and mathematics teaching anxiety. *International Journal of Human and Social Sciences*, *5*(9), 610–613.

Zettle, R., & Raines, S. (2000). The relationship of trait and test anxiety with mathematics anxiety. *College Student Journal*, *34*(2), 246–258.

APPENDICES

Appendix A – Demographic Questionnaire

Thank you for considering to participate in this study.

The survey will take approximately 20 minutes to complete. If you are willing to complete the survey please read the consent to participate in research below and proceed to subsequent pages (by clicking on the next button) to answer the questions.

1. Please write your name (or nickname)

   ____

2. Please provide personal (non-professional) email address

   ____

3. What is your gender?

   Male Female Other Choose not to answer

4. In which ethnic or cultural group do you belong to?

   White Hispanic or Latino Black or African American/Canadian

   Asian / Pacific Islander Aboriginal (First Nations, Metis, Inuit, Native American)

   Middle Eastern Other (Please specify)

5. Which of socioeconomic status do you consider yourself to belong during your elementary school years?

   Low Middle High

6. What was the highest educational level that your parents/caretakers had/obtained during your elementary school years?

   Mother: Elementary or less High School Graduate Bachelor's Degree

   Master's Degree and Above Not Applicable

   Father: Elementary or less High School Graduate Bachelor's Degree

   Master's Degree and Above Not Applicable

7. How long have you been teaching elementary school students (that is, Grades 1 to 8)?

   1 - 3 years 4 - 6years 7 - 10 years

   More than 10 years

8. What Grade(s) are you currently teaching? ______________________________

   Low   Moderate   High

9. What is the highest level of mathematics you have studied in school?
   Grade 10   Grade 11   Grade 12   College   University

10. Have you ever experienced “mathematics anxiety”? (that is the feelings of tension, nervousness, fear, worry, and stress that one experience when dealing with mathematics, numbers, and calculations in academic situations and everyday life) If No, please go to question 13
    Yes   No

11. What do you perceive your current level of mathematics anxiety to be?
    Low   Moderate   High

12. Do you remember when you first experienced mathematics anxiety?
    Elementary school (1-5)   Middle school (6-8)   High school (9-12)

    College   University   Don’t remember   Never

13. Have your mathematics anxiety diminish with time?
    Yes   No

14. Do you experience mathematics teaching anxiety? (that is feelings of tension and stress that one experience when teaching mathematics concepts, formulae, or theorems)
    Yes   No

15. What is your perceived level of understanding of Grade 1 to 8 mathematics concepts and material that you teach?

Appendix B – Revised Mathematics Anxiety Rating Scale (RMARS)

FOR EACH OF THE FOLLOWING ITEMS, INDICATE HOW MUCH THE SITUATION FRIGHTENS YOU

Use a five-point scale ranging from 1 (not at all) to 5 (very much)

	not at all				very much
1. Buying a mathematics textbook	1	2	3	4	5
2. Watching a teacher (or student) work on an algebraic equation on the blackboard	1	2	3	4	5
3. Signing up for a math course	1	2	3	4	5
4. Listening to another student (or teacher) explain a math formula	1	2	3	4	5
5. Walking into a math class	1	2	3	4	5
6. Studying for a math test	1	2	3	4	5
7. Taking math section of college entrance exam	1	2	3	4	5
8. Reading a cash register receipt after your purchase	1	2	3	4	5
9. Taking an exam (quiz) in a math course	1	2	3	4	5
10. Taking an exam (final) in a math course	1	2	3	4	5
11. Being given a set of numerical problems involving addition to solve on paper	1	2	3	4	5
12. Being given a set of subtraction problems to solve	1	2	3	4	5
13. Being given a set of multiplication problems to solve	1	2	3	4	5
14. Being given a set of division problems to solve	1	2	3	4	5
15. Picking up math textbook to begin working on a homework assignment	1	2	3	4	5
16. Being given homework assignments of many difficult problems that are due the next class meeting	1	2	3	4	5
17. Thinking about an upcoming math test 1 week before	1	2	3	4	5
18. Thinking about an upcoming math test 1 day before	1	2	3	4	5

FOR EACH OF THE FOLLOWING ITEMS, INDICATE HOW MUCH THE SITUATION FRIGHTENS YOU

Use a five-point scale ranging from 1 (not at all) to 5 (very much)

	not at all			**very much**	
19. Thinking about an upcoming math test 1 hour Before	1	2	3	4	5
20. Realizing you have to take a certain number of math classes to fulfil requirements	1	2	3	4	5
21. Picking up math textbook to begin a difficult reading assignment	1	2	3	4	5
22. Receiving your final math grade in the mail	1	2	3	4	5
23. Opening a math or stat book and seeing a page full of problems	1	2	3	4	5
24. Getting ready to study for a math test	1	2	3	4	5
25. Being given a “pop” quiz in a math class	1	2	3	4	5

Appendix C – Mathematics Teaching Anxiety Scale-English Version (MATAS-E)

Use a five-point scale ranging from 1 (I agree absolutely) to 5 (I absolutely don't agree)

- I feel that I do not know anything about mathematics topics that I am going to teach
- I afraid of showing the mathematics problems that I am going to solve during teaching to other teachers
- It is very difficult for me to remember mathematical formulas while solving mathematics problems
- I feel desperate while teaching mathematics
- I feel uneasy when talking about teaching some of mathematics topics
- I am unsuccessful in solving mathematics problems
- I am afraid of teaching mathematics
- I think that I feel uneasy while teaching mathematics
- It is very difficult for me to teach mathematics
- I think that it is really hard for me to teach mathematics concepts
- I think that I feel comfortable in teaching mathematics
- I feel talented in solving mathematics problems
- It is very easy for me to teach mathematics
- I am always successful in solving mathematics questions
- I think that I feel comfortable when I come across with a new mathematics problem
- I think that I always feel comfortable in a mathematics class
- I think that I enjoy teaching mathematics
- I think that it is a pleasure for me to teach mathematics
- I like to reply to questions regarding the mathematics topic I am teaching
- I like to illustrate how to solve mathematics problems to others
- I think that I can use different theories and perspectives about mathematics teaching during my teaching professional life
- I can use the ways to access information and research methodologies on mathematics teaching during my professional teaching period
- I can use the knowledge and skills related to special education strategies while teaching mathematics

You have come to the end of the survey. Thank you for completing the survey.

By submitting these answers, you consent to participate in the study.

Appendix D –Interview Questions

1. As a student, describe your feelings about mathematics (past feelings).
2. As a teacher, describe your feelings about mathematics (current feelings).
3. Was there an event that induced your mathematics anxiety? Please explain.
4. Why do you think teachers develop mathematics teaching anxiety?
5. Do you feel that the social environment (influences of teachers/parents/friends/media/ culture/other) contributed to your developing mathematics anxiety? (Yes or No) Please explain.
6. How have the feelings of mathematics anxiety affected you personally and professionally?
7. What strategies have you employed in coping with, reducing, or overcoming mathematics anxiety?
8. How successful were you (in your own view) in coping with, reducing, or overcoming mathematics anxiety? What supports may you still need to reducing or overcoming your mathematics anxiety?
9. Do you think mathematics anxiety could be transferred to students? (Yes or No) Why?
10. What advice would you give a teacher who is experiencing mathematics anxiety?

Appendix E

LETTER OF INFORMATION FOR CONSENT TO PARTICIPATE IN RESEARCH

TITLE OF STUDY: **Investigating and Overcoming Mathematics Anxiety in In-service Elementary School Teachers**

You are asked to participate in a research study conducted by AtinukeAdeyemi, a PhD Candidate, from the Faculty of Education at the University of Windsor. The results of the study will contribute to her Doctoral Dissertation.

If you have any questions or concerns about the research, please feel to contact AtinukeAdeyemi by phone- 519 253 3000 Ext. 3803 or email – adeyemia@uwindsor.ca. You can also contact her academic supervisor Dr. Dragana Martinovic by phone: (519) 253-3000 Ext. 3962 or email: dragana@uwindsor.ca.

PURPOSE OF THE STUDY

The purpose of the study is to examine the nature (levels, causes, and effects) of mathematics anxiety that exists among in-service elementary school teachers in Southern Ontario and how this anxiety differs by gender and other demographic factors, including socio-cultural. Socio-cultural factors include ethnicity and influences of parents, teachers, counsellors, and peers. The study will also investigate the kind of mathematics teaching anxiety that exists among in-service elementary teachers. It is set to suggest ways to alleviate mathematics anxiety among teachers and their students.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

a) Complete three survey instruments online that will be forwarded through your Board to your active email address with the school board. The three survey instruments will take about 20 minutes to complete. The first instrument is a demographics questionnaire that contains questions related to factors that are associated with mathematics anxiety. The second instrument contains questions related to mathematics anxiety and how you would feel in given situations. The third instrument contains questions related to mathematics teaching anxiety. On request, the hard copy of the survey instruments will be mailed or sent as a word document attachment to you in case you prefer to complete the survey that way.

b) Provide your personal contact information, specifically your name and personal e-mail address when completing the survey in case you are selected for a voluntary interview.
c) If selected for interview, you will be contacted through your personal email to participate in a one – to – one interview with me which will be audio taped and take about 45 minutes. During the interview you will be asked to talk about your past experiences on mathematics anxiety and your strategies for coping with, reducing or overcoming it.

Data collection for this study will last not more than 8 weeks. Interview with the selected participants will take place at the University of Windsor or your prefer locations, such as Public Library, Tim Horton, or School Library. The data collected during the interview will be transcribed and given to you for verification. No evaluative judgment will be made about you in case of withdrawal from the study. In such case, all raw data collected from you will be immediately destroyed. The School Boards will not have any access to all the data collected for the study and you may choose not to answer any question that you are not comfortable with during the study.

POTENTIAL RISKS AND DISCOMFORTS

There are no major known risks and discomforts anticipated (including for example, physical, psychological, emotional, or financial) for the participants in this study. I will make every possible effort to safeguard the data retrieved from participants. Data from the survey will be stored at the University of Windsor secured server. The School Boards involved will not have access to the data. A potential emotional risk could arise during the interviews as participants could be upset or embarrassed over the recall of past experiences and influences on their mathematics anxiety. In this case, I will provide support and offer the participants positive verbal and non-verbal encouragement that would create a sense of safety.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

By participating in the research, participants will be made aware of issues related to mathematics anxiety, its types, levels, and consequences, as well as the impact on the students. Participants will benefit from the recommendations that will be provided through the study on how to cope with or reduce mathematics anxiety and how to prevent the transfer of mathematics anxiety to students in the classrooms as well as how to meet the needs of the students who may be suffering from mathematics anxiety.

The findings of this research study will inform policy makers, academics, and school boards, similar to those involved in the research, about how to meet the needs of elementary school teachers and other individuals who may be suffering from mathematics anxiety.

COMPENSATION FOR PARTICIPATION

There will be no any reimbursements, remuneration or other compensation that will be provided to the participants in this study.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.The data collected will be downloaded on a computer and will be password protected. Password to access the data will be kept by the researcher and her supervisor. Your true name will be replaced by pseudonym so as to protect your identity and any information, such as location of school, from which your identity could be inferred will not be reported.

At all times (till the data are destroyed) you will have right to review the audio recordings with your interviews. These documents will not be used for any other purpose except for this research and will be destroyed two years after the completion of the study.

PARTICIPATION AND WITHDRAWAL

The online survey has "Exit Survey" button at the bottom of survey pages. This option will allow you to exit the survey, not submitting any responses you have provided in case you may want to withdraw from the study. Upon withdrawal from the study, your data will be destroyed and excluded from analyses. There will be no consequences or penalty for withdrawal from the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

The research findings will be shared with all interested participants before its publication. Dissemination will be done through workshops organised for teachers during the professional development day and through seminars and conferences. The results of this study are expected to be made available by December 2015. The results of the study will be posted on Research Ethics Board, University of Windsor webpage, (www.uwindsor.ca/reb under Study Results). All participants will have open access to this webpage.

SUBSEQUENT USE OF DATA

These data may be used in subsequent studies, in publications, and in presentations.

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights as a research participant, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH PARTICIPANT

I understand the information provided for the study “Investigating and Overcoming Mathematics Anxiety in In-service Elementary Teachers” as described herein. My questions have been answered to my satisfaction and I agree to participate in this study by clicking the “Submit” button on the survey.

Appendix F

CONSENT FOR AUDIO TAPING OF THE INTERVIEW

Participant Name (print): ____

Title of the Project: **Investigating and Overcoming Mathematics Anxiety in In-service Elementary School Teachers**

I consent to the audio-taping of interviews.

I understand these are voluntary procedures and that I am free to withdraw at any time by requesting that the taping be stopped. I also understand that my name and any other identifying information that may be associated with the audio recording or the transcript from the interviews will not be revealed to anyone and that taping will be kept confidential. In the case that you withdraw from the interview your recoding will not be used in this research. Audio files will be kept on a CD filed by a number only and stored in a locked cabinet for a period two years after which they will be destroyed by the researcher.

I understand that confidentiality will be respected and that the audio tape will be for professional use only.

______________________________ (Research Participant)

______________________ (Date)

Appendix G: Research Ethics Board Clearance

Today's Date: February 26, 2014
Principal Investigator: Ms. Atinuke Adeyemi
REB Number: 31411
Research Project Title: REB# 14-025: "Investigating and Overcoming Mathematics Anxiety in In-Service Elementary School Teachers"
Clearance Date: February 26, 2014
Project End Date: November 01, 2015
Milestones:
Renewal Due-2015/11/01(Pending)

This is to inform you that the University of Windsor Research Ethics Board (REB), which is organized and operated according to the Tri-Council Policy Statement and the University of Windsor Guidelines for Research Involving Human Subjects, has granted approval to your research project on the date noted above. This approval is valid only until the Project End Date.

A Progress Report or Final Report is due by the date noted above. The REB may ask for monitoring information at some time during the project's approval period.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the REB. Minor change(s) in ongoing studies will be considered when submitted on the Request to Revise form.

Investigators must also report promptly to the REB:

a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;

b) all adverse and unexpected experiences or events that are both serious and unexpected;

c) new information that may adversely affect the safety of the subjects or the conduct of the study.

Forms for submissions, notifications, or changes are available on the REB website: www.uwindsor.ca/reb. If your data is going to be used for another project, it is necessary to submit another application to the REB.

We wish you every success in your research.

Pierre Boulos, Ph.D.
Chair, Research Ethics Board
Lambton Tower, Room 1102A
University of Windsor
519-253-3000 ext. 3948
Email: ethics@uwindsor.ca

Appendix H – List of Codes Identified Across Interview Data Set

Environmental Factors

Teachers Influences

Fast paced instruction

Mean behavior

Derogatory remark

Lack of mathematics review

Peer pressure

Poor preparation

Parental expectations

Encouragement/lack of encouragement

Extra help in mathematics

Tutoring support

Personal Factors

Lack of understanding of mathematics lesson

Gaps in knowledge

Feelings of lack of success

Inferiority feelings

Lack of self-confidence

Peer aptitude

Personal struggles

Uncomfortable with mathematics

Motivated to teach and behave differently

Fear of mathematics

Mathematics avoidance

Memorization versus application of mathematics

Behavioral Factors

Alternative teaching methods

Deals with different learning styles

Correcting mistake

Lesson preparation

Learning independently

Building relationship

VITA AUCTORIS

NAME:	Atinuke Yemisi Adeyemi
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EDUCATION:	Bachelor of Science (Mathematics) University of Ibadan, Ibadan, Nigeria, 1994
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