Abstract

Title of dissertation: DO K, 1, 2 TEACHERS WHO PARTICIPATED IN A YEAR LONG MATH COURSE HAVE LESS TEACHER MATH ANXIETY THAN THOSE WHO DID NOT PARTICIPATE?

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The purpose of this study was to determine if participation in a Year Long Math Course (YLMC) for professional development would reduce teacher personal or professional math anxiety. Through a quantitative study using the McAnallen Anxiety in Mathematics Teaching Survey, the researcher measured the personal and professional math anxiety of participants and analyzed the data to determine if teachers who participated in a year -long math course had less anxiety than those who did not participate. All teachers involved in the study were considered generalists at the elementary level. Through use of the McAnallen Anxiety in Mathematics Teaching Survey, the study provided data that could be used to inform professional development training for pre-service and in-service elementary teachers. The study could also be used to support strengthening of mathematics programs in pre-K through 12 education.

DO K, 1, 2 TEACHERS WHO PARTICIPATED IN A YEAR LONG MATH COURSE HAVE LESS TEACHER MATH ANXIETY THAN THOSE WHO DID NOT PARTICIPATE?

by

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Dedication

Philippians 4:13

I can do all things through Christ who strengthens me

To my parents, Rod & Carolyn Reed (Hotrod & Moonshine), you sacrificed much so that we could grow up in a solid, Christ-centered home where morals and education were paramount. I am blessed beyond measure by your fathomless love for me. Mom, you were my source of inspiration in this program when I wanted to give up, because I look at you and your spunk and resilience and think…you have defied the odds time and time again, the least I can do is finish my coursework and dissertation. This is for you. I love you a bushel and a peck and a hug around the neck (and a chicken dance too!).

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"Most obstacles melt away when we make up our minds to walk boldly through them" – Orison Swett Marden

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“Gratitude is the memory of the heart” - Jean Baptiste Massieu

Thank you.

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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 the generations to come (Williams, 1988, p. 101).

Basic math skills are important for everyday life, however, “many people report feeling anxious when faced with the prospect of doing math” (Lyons & Beilock, 2012, p. 2102). Mathematics anxiety is characterized by feelings of stress, angst, and panic in regards to performing math and is associated with delayed acquisition of number concepts and with poor math competence (Richardson & Suinn, 1972). According to the National Mathematics Advisory Panel (NMAP) (2008), math anxiety is an impediment to math achievement and effects teachers and students (National Mathematics Advisory Panel (NMAP), 2008). Math anxiety typically begins in elementary school and often impacts the choices of students in taking math courses and advanced math courses in high school (Scarpello, 2007). A recent study found that teachers of grades one and two with high math anxiety affected the math performance of their students and their students’ beliefs about their personal math ability (Sparks, 2011). According to the National Research Council (2007), 75 percent of Americans stop studying math before they have completed the educational requirements for their career or job. The NMAP (2008) asserts the safety of our nation and quality of life, in addition to the prosperity of the nation, are at the heart of the need to improve mathematics education. Job opportunities in science and engineering are "expected to outpace job growth in the economy at large" (NMAP, 2008, p. xii) while the number of retirements in those sectors is expected to accelerate. These trends will place significant stress on the nation's capacity to sustain a workforce with adequate scale and quality.

Education is increasingly essential to prepare students for a rapidly changing world, and in order to be globally competitive, they must be able to apply knowledge in order to solve complex problems, communicate and collaborate effectively, and find and manage information (Friedman, 2005). For years it has been clear that the U.S. mathematics curriculum is "a mile wide and an inch deep" (Schmidt, McKnight, & Raizen 1997, p. 33) and that the fragmented quality of mathematics instruction is related to our low ranking on international assessments (National Research Council, 2007).

> The Nation is now well into the 21st century and not since the Soviet Union's launch of the *Sputnik* satellite – 47 years ago – has the need to improve science and mathematics education in America been as clear and as urgent as it is today (NSB, 2006, p. 5).

President Obama has conveyed a sense of urgency to excel in the global economy, specifically through excellence in mathematics and science, throughout both of his campaigns and his time in office. The sense of urgency has also been conveyed in numerous reports, including one that asserted that the need to excel in mathematics and science must be addressed in K-12 education now (NSB, 2006). Ten years ago, another report asked: "As our children move toward the day when their decisions will be the ones shaping a new America, will they be equipped with the mathematical and scientific tools needed to meet those challenges and capitalize on those opportunities?" (The National Commission on Mathematics and Science Teaching for the 21st Century, 2000, p. 6).

> For over a decade, research studies of mathematics education in high performing countries have pointed to the conclusion that the mathematics curriculum in the United States must become substantially more focused and coherent in order to improve mathematics achievement in this country. To deliver on the promise of common standards, the standards must address the problem of a curriculum that is "a mile wide and an inch deep." (Common Core State Standards Initiative (CCSSI), 2012a, p.3).

The Common Core State Standards (CCSS) standards are a substantial answer to that challenge. The CCSS were developed by the Council of Chief State School Officers and the National Governors Association Center for Best Practices, in concert with other stakeholders. Forty-five states and three territories have adopted the CCSS for literacy and mathematics (CCSSI, 2012a).

William Schmidt and Richard Houang conduct research for Achieve, an organization that oversees research to support education initiatives. They recently completed a study evaluating the alignment of the CCSS for mathematics to individual state standards in the United States versus standards of other nations. Schmidt and Houang's study concluded by stating that the most urgent issue with common core implementation and success is "we don't yet know if teachers will receive the preparation and support they need to teach mathematics in a fundamentally new way" (Schmidt, 2012, p. 24).

Statement of the Problem

One important component in supporting teachers in the implementation of the new standards is to address teacher math anxiety in an effort to assure it does not interfere with mathematics instruction. Therefore, the purpose of this study was to determine if teachers of grades kindergarten, one, and two who participate in yearlong mathematics professional development, called Year Long Math Course (YLMC), have less anxiety than teachers who did not participate in YLMC.

A teacher's anxiety and attitude toward mathematics can be transmitted to students through instruction, or lack thereof, and may have a significant negative impact on students' mathematical experiences and attitudes. Math-anxious elementary teachers who avoid teaching mathematics put their students at a significant disadvantage in mastering grade level mathematics (Hembree, 1990; Scarpello, 2007; Sherman & Christian, 1999). The implementation of the CCSS requires a deeper understanding of mathematical content and, particularly in intermediate elementary grades, deep knowledge and application of skills that have been traditionally taught in middle school. Elementary teacher math anxiety must be identified and strategically addressed to ensure our students are empowered with the mathematical knowledge and skills to be successful in an ever-changing world.

Dreger and Aiken (1957) identified and researched math anxiety over sixty years ago. Recently, an increased concern regarding the quality of elementary mathematics instruction has brought math anxiety to the attention of elementary schools and colleges that provide undergraduate teacher preparation. The expectations for school systems have increased, requiring an elementary teacher work force with stronger mathematical content knowledge and pedagogy than in the past. Research has indicated the level of math anxiety pre-service teachers experience is widespread. Teacher skill in mathematics can be limited by math anxiety, which may also be transmitted to elementary students (Gresham, 2007a; Malinsky, Ross, Pannells, & McJunkin, 2006; Swars, 2006).

The concerns surrounding math anxiety served to focus the present study on the preparation of teachers in grades kindergarten, one, and two to teach mathematics content required by the CCSS. Student achievement in mathematics has become increasingly important in determining the success of schools. The importance of math achievement has perpetuated teacher education programs to examine, and attempt to address, math anxiety (Brady & Bowd, 2005, Gresham, 2007a; 2007b; Malinsky et al., 2006; Sloan et al., 2002; Swars, 2006).

The National Council for Teachers of Mathematics (NCTM) maintains that by gaining competence in mathematical skills, teachers will have less anxiety about, and more success in teaching, mathematics (National Council for Teachers of Mathematics (NCTM), 2009). Previous research (Brady & Bowd, 2005; Gresham, 2007a) has revealed statistically significant reductions in mathematics anxiety in pre-service teachers who completed a mathematics methods course focused on skills, concepts, and processes of mathematics. The National Mathematics Advisory Panel notes that mathematics professional development for elementary and middle school teachers must be strengthened to improve teacher effectiveness in mathematics. They state “teachers must know in detail and from a more advanced perspective the mathematics content they are responsible for teaching and the connections of the content to other important mathematics, both prior to and beyond the level they are assigned to teach" (NMAP, 2008, p. xxi). This study seeks to address the following question:

> Is there a difference between the math anxiety, as assessed using the McAnallen Anxiety of Mathematics Teacher Survey for Tyner County Public Schools (MAMTS-TCPS), of kindergarten, first and second grade teachers who participated in Year Long Math Course and the math anxiety of teachers teaching the same grades who did not participate in Year Long Math Course?

Limitations of the Study

The findings of this study are limited to elementary teachers in TCPS who participated in Year Long Math Course (YLMC). Participation in YLMC is not open to all teachers. Each of the 27 elementary principals may send one teacher from each grade (kindergarten, grade one, grade two) to participate in YLMC. YLMC participants receive state credit, rather than being paid for their time, and are expected to assume mathematics leadership in their buildings. The study is limited to grades kindergarten, one, and two because YLMC was only offered for teachers of those grades during the 2012-13 school year. The participants, selected by principals, have varying levels of experience, and some have previously participated in YLMC. The researcher is the current prekindergarten through twelfth grade mathematics supervisor for Tyner County Public Schools (TCPS). Participants were completely anonymous. No identifying information, such as gender, ethnicity, school demographics, or size of grade level team, was collected in an effort to further ensure anonymity. Finally, the effectiveness of the YLMC facilitators, who have been formally observed and have worked in the elementary mathematics office for four to eight years, is not a component of this study.

Assumptions

The study is based on the assumption that the primary cause of math anxiety is the confidence and competence of elementary teachers. Therefore, it was assumed that participation in professional development addressing content, conceptual understanding, and pedagogy would reduce teacher math anxiety. For the purpose of this study, it should be assumed that the total teaching population in TCPS is not fully represented. Data from the study reflect that YLMC participants surveyed were representative of the sample in years as a classroom teacher, current grade level taught, years at current grade level, and number of high school courses taken. The only difference reflected in the MAMTS-TCPS between the YLMC participants and non-YLMC participants was the YLMC participants have participated in more TCPS professional development offerings in the last three years.

Methodology

This quantitative study was conducted using a quasi-experimental research design. Quasi-experimental research is a model that allows "the researcher to answer critical questions about the relationship between variables ("Did X cause Y?")" (Butin, 2010, p. 85) and whether there are significant differences between variables. The model was used to determine if teachers of kindergarten, grade one and grade two who participated in yearlong professional development have less teacher math anxiety than those who did not participate. In TCPS, there are a total of 166 teachers in grades kindergarten, one, and two. All of the teachers were asked to complete the survey.

Importance of Study

"In this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. A lack of mathematical competence keeps those doors closed" (NCTM, 2000, p.50). Teacher preparation programs for elementary certifications lack comprehensive coursework in mathematics and mathematics teaching. Ball, Hill, & Bass (2005) assert that pre-service programs must include courses that address the mathematics content specific to the grade levels of teacher certification. Many elementary teachers enter the field lacking the depth and breadth of mathematics content knowledge and confidence to effectively teach mathematics. Rech, Hartzell, and Stephens (1993) compared college students majoring in elementary education to the general college population and found that elementary education majors had poorer attitudes about math and decreased math competence. Additionally, studies have shown that many enter the profession with math anxiety and attitudes about mathematics that are not as positive as their attitudes about other content areas (Kelly & Tomhave, 1985; Hembree, 1990). Marilyn Burns describes math as an American phobia "right up there with snakes, public speaking, and heights" (1998, p.ix). Negative feelings toward mathematics have permeated our culture and have perpetuated math anxiety. Research suggests that most Americans have had negative school experiences with mathematics (Jackson & Leffingwell, 1999) and that up to fifty percent of Americans experience mathematics anxiety (Burns, 1998; Jones, 2001).

As TCPS transitions to the CCSS, reducing teacher math anxiety is increasingly important to building a culture that supports student success. The supervisor of prekindergarten through twelfth grade mathematics must strategically plan for professional development and supports that may reduce teacher math anxiety. Additionally, the study will add to a small body of research on the impact of professional development on teacher math anxiety.

Definition of Terms

Building Level Lead Teachers: Building level lead teachers in TCPS are individuals (one per building for most schools, large schools have two) who support all teaching staff of all contents in each school. They do not have a class of students assigned to them and are responsible for instructional support, mentoring, meeting facilitation, and general professional development. They are not content specialists.

Common Core State Standards (CCSS): The Common Core State Standards Initiative is a United States education initiative sponsored by the National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO). In 2010, CCSS were released for English language arts and mathematics. Educational standards provide clear goals for student learning and support teachers in ensuring students have the skills and knowledge they need to be successful. "The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy" (CCSSI, 2012a).

Conceptual Knowledge: Conceptual knowledge is the knowledge of mathematical relationships and understanding of the relationships. It is the comprehension of mathematical concepts, operations, and relations. Conceptual knowledge cannot be learned by rote, but requires understanding of mathematical concepts and skills to apply the relationships and understanding to problems (Van de Walle, Karp, & Bay-Williams, 2010).

Elementary Mathematics Central Office Lead Teachers: Elementary central office lead teachers are teachers in TCPS who work with the mathematics supervisor to support elementary schools in the content and pedagogy for elementary mathematics. These teachers visit classrooms, support new teachers, facilitate professional development, and work with Building Level Lead Teachers to support their mathematical content and pedagogical knowledge.

Elementary School: School for students in grades prekindergarten through grade 5.

Math Anxiety: Characterized by fear of doing mathematics. Math anxiety is often the result of teaching that is focused on memorization and applying mathematical rules with little or no understanding, which leads to the inability to recall the rules and memorized information.

Mathematical Content Knowledge: Mathematical content knowledge is the knowledge of mathematical processes, procedures, concepts, and generalizations required to teach mathematics (Van de Walle, et al., 2010).

Pedagogical Knowledge: Pedagogical knowledge is the understanding of "how children learn mathematics, including a keen awareness of the individual mathematical development of students" (Van de Walle, et al., 2010, p. 2). It encompasses "...the content, skills, and strategies required for effective teaching" (Gerges, 2001, p.72).

Pre-Service Teacher: An individual who has chosen to go into the field of education and who is completing training to be a teacher but has not yet received the credentials to teach.

Procedural Knowledge: Procedural knowledge is the knowledge of the formal language, rules, algorithms, and procedures of mathematics.

Year Long Math Course (YLMC): Year Long Math Course is a yearlong professional development course that was first offered in 2009-2010 for each elementary grade. The original purpose of YLMC was to support teachers in their understanding of the Maryland State Curriculum and the deepening of their content knowledge and pedagogy. Beginning in the 2012-2013 school –year, YLMC began to focus on the Common Core State Standards and teacher content and pedagogy necessary to support student achievement and success on the CCSS.

Chapter 2: Review of Literature and Research

Introduction

The purpose of this study was to determine if teachers who participate in yearlong mathematics professional development, called Year Long Math Course (YLMC), have less math anxiety than teachers who did not participate in YLMC. A quantitative study methodology was used, and participants completed an online survey, the MAMTS-TCPS, to determine the level of participant personal and professional mathematics anxiety.

A comprehensive review of literature on math anxiety is provided in this chapter. The literature review includes six sections. The first section is a review of the definitions of math anxiety. The second section provides a review of the effects of math anxiety on elementary teachers and on the mathematics achievement of students. Section three provides a review of teacher preparation programs and content background of elementary teachers. The fourth section provides a review of documented methods of addressing math anxiety. Section five provides a review of prior research on elementary teacher math anxiety. Finally, the sixth section provides background on the Common Core State Standards (CCSS) and the implications for elementary teachers.

Definitions of Math Anxiety

Fears from past experiences with mathematics are a leading cause of math anxiety in teachers (Harper & Daane, 1998). As Tobias (1990) pointed out, math anxiety is also felt when using mathematical algorithms, discussing math, or even taking a math test. Mathematics educators have known of math anxiety for years (Gresham, 2007a; Sloan et al., 2002). Almost sixty years ago, the book *Mathemaphobia: Causes and Treatments* stated: “Mathemaphobia needs no defining. The term is self-definitive. The prevalence of the disease, however, does call for a concerned effort to educate the public against its insidious attacks" (as cited in McAnallen, 2010). Initial research and awareness of the phenomenon of math anxiety began with teacher observation in the early 1950s by Dreger and Aiken (1957) who were the first to present the term *number anxiety*. Their study was initiated by interest in detecting the presence of an adverse emotional response to mathematics that they termed number anxiety. They hypothesized that number anxiety was distinct from general anxiety, that number anxiety was not related to intelligence, and that individuals with high number anxiety would tend to have lower grades in mathematics. The conclusion of the study indicated that number anxiety does not appear to be related to intelligence and individuals with higher number anxiety are more likely to have lower grades in mathematics. Number anxiety was determined to be "the presence of a syndrome of emotional reactions to arithmetic and mathematics" (Dreger & Aiken, 1957, p. 344). As a result, Dreger and Aiken agreed on a consistent set of criteria to define math anxiety as an "emotional disturbance in the presence of mathematics" (p. 344). This preliminary work on math anxiety showed, for the first time, that it was a separate and unique syndrome, not related to general anxiety or intelligence, but it was related to poor performance consequently affecting achievement in school. The study prompted further research into the syndrome, with several goals in mind, not the least of which was to begin to more precisely define math anxiety (Dreger & Aiken, 1957).

Researchers since Dreger and Aiken (1957) have generated multiple, but similar, criteria to explain, or define, math anxiety. Math anxiety is a loathing of mathematics (Vinson, 2001) and a condition of distress that occurs when someone is asked to perform mathematics (Wood, 1988). It is also characterized as worry, stress, weakness or general ineffectiveness an individual has when required to manipulate numbers and shapes (Richardson & Suinn 1972; Tobias, 1978). Math anxiety can lead to incapacitation, fear of, or evasion of, mathematics (Tobias, 1978), or fright or nervousness when confronted with numbers (Sherman & Christian, 1999; Tobias & Weisbrod, 1980). It is defined as a mild to extreme feeling of uncertainty regarding mathematics (Gresham, 2007a, 2007b); and as not being able to do well with numbers (Tobias, 1993). Some researchers have described it as an intense, negative, emotional reaction to anything mathematical (Sherman & Christian, 1999). Mathematics anxiety was defined by Richardson and Suinn (1972), who developed the Mathematical Anxiety Rating Scale (MARS), as “feelings of tension and anxiety that interfere with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations” (p. 544). Mathematics-related distress is accompanied by symptoms, including dread, nervousness, and an increased heart rate (Fennema & Sherman, 1976). Hendel and Davis (1978) described mathematics anxiety as intentional avoidance of mathematics and the inability to learn mathematics skills. Furthermore, Tobias and Weisbrod (1980) defined mathematics anxiety as “the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem” (p. 63).

Ferguson (1986) classified mathematics anxiety into three categories: mathematics test anxiety, numerical anxiety (related to manipulating numbers), and abstraction anxiety (related to understanding abstract mathematical content). Byrd (1982) described it as any situation where one experiences anxiety "when confronted with mathematics in any way" (p. 38). Handler (1990) stated that mathematics anxiety represents an anxious state induced by fear of failing when attempting to learn or to demonstrate one's learning of mathematics, and she implied that mathematics anxiety may result in a high level of emotional interference that can disrupt memory. Gresham (2004) and Bursal and Paznokas (2006) described mathematics anxiety as a lack of applied understanding and/or an irrational dread of mathematics, often leading to avoidance of the subject. Zettle and Raines (2002) noted that the distress can result in a negative attitude toward mathematics. Various definitions of mathematics anxiety suggest that it can result in fear, distress, shame, inability to cope, sweaty palms, nervous stomach, difficulty in breathing, and a loss of ability to concentrate (Burns, 1998; Bursal & Paznokas, 2006; Dutton & Dutton, 1991; Hembree, 1990).

Another source of mathematics anxiety is the so-called "math myths" (Preis & Biggs, 2001) including such statements as:

> Women can't do math; Some people can do math, others can't; My father/mother couldn't do math, either; I'm good at English – that's why I'm so bad at math; Insights into math have come to you instantly; and If you can't solve the problem instantly, you should just quit (Preis & Biggs, 2001, p. 6).

Preis and Briggs believe that it is more acceptable to say, "I'm not good at math," than it is to say, "I can't read". They further explain that if a student encounters a level difficulty in reading, he or she often quits and comes back to it later, while with a difficult mathematics problem, students believe they must get it on the first try or they will never solve it (Preis & Biggs, 2001). According to Ashcraft (2002), "aptitude is considered to be far more important than effort in mathematics by most individuals" (p. 181). Commonly expressed sentiments about mathematics perpetuate the myth that real mathematical understanding is available to a limited number of people. Burns gives similar examples to Preis and Biggs: “only some people are good at math”, “you’re only good in math if you have the math gene.” “People who are good in math wear thick eyeglasses and plastic pocket protectors” (p.ix).

Hadfield and McNeil (1994) define three causes of mathematics anxiety: environmental, intellectual, and personality factors. They cite the work of Dossel and Tobias in defining environmental factors as negative experiences due to parental and teacher expectations, the manner in which math is presented, and inflexible classroom environments. Research by Cemen, Miller and Mitchell is cited to define intellectual factors such as being taught through incompatible learning styles, poor student attitude, lack of self-confidence, and lack of understanding regarding the usefulness of mathematics. Finally, research on articulating personality factors is attributed to Cemen, Gutbezahl, Levine, Miller and Mitchell. Personality factors include perceptions that math is predominately for men, adversity to asking questions, and low self-esteem (as cited in Hadfield and McNeil, 1994). These factors have implications for classroom teachers, both in their own math anxiety, but also in counteracting math anxiety in their students.

Effects of math anxiety on teachers and elementary student achievement

Research about mathematics anxiety has been largely spurred by increasing perceptions that it threatens student achievement. These suggestions have national importance; because when capable students avoid mathematics their career options are reduced, which could result in eroding the country‘s resource base in science and technology (Hembree, 1990, p. 34). Research by Jackson and Leffingwell (1999) has shown that only about 7% of Americans have had positive experiences with mathematics from kindergarten through college. In 1992, researchers at the University of Florida circulated a questionnaire to 9,093 students and found that 25.9% had a moderate to strong need of help with mathematics anxiety (Jones, 2001). Burns (1998), estimated that two thirds of Americans fear or loath mathematics. Although mathematics anxiety has been identified as a learning difficulty for many children (Dossel, 1993), it has been reported that a disproportionately large percentage of elementary teachers experience high levels of mathematics anxiety (Buhlman & Young, 1982; Levine, 1996). The preponderance of teacher math anxiety yields concern regarding their effectiveness in teaching mathematics to children (Trice & Ogden, 1986). The literature reflects that math anxious teachers tended to be math anxious students. Math anxiety can cause students to develop low self-esteem that promotes a self-fulfilling prophecy of academic failure. Because mathematics teachers are former students, if they have a low self-concept with regard to academic failure in mathematics, they might have a tendency to avoid teaching math (Gresham, 2007a). Research suggests that pre-service teachers experience higher levels of mathematics anxiety than other university students (Battista, 1986; Harper & Daane 1998; Trujillo & Hadfield, 1999; Wood, 1988).

According to Wood (1988), pre-service teachers are a "significant minority when compared to other university students" (p. 93). Hembree (1990) reported that the level of mathematics anxiety of pre-service elementary teachers was the highest of any major on university campuses. Recent studies have suggested that pre-service teachers with high levels of mathematics anxiety have demonstrated low confidence to teach elementary mathematics (Bursal & Paznokas, 2006). Buhlman and Young (1982) hypothesized that "in general, the kind of person who is drawn to elementary teaching is not necessarily the kind who enjoys mathematics in the broad sense – from its logical beauty to its real world application" (p. 55). These researchers found that most elementary education students identified mathematics as their worst subject and had little or no need for a higher level of mathematical skills beyond computation. The researchers also found other factors that contributed to the development of mathematics anxiety such as the ways mathematics were presented and taught; self-perceptions; family influences, and mathematics test anxiety. Many of the students in these studies described fear, failure, and subsequent avoidance of mathematics (Ellsworth & Buss, 2000; Silva & Roddick, 2001).

Math anxiety among elementary teachers is a concern in regards to the effectiveness of elementary teachers in teaching mathematics and transference of math anxiety to their students (Harper & Daane 1998; Hembree, 1990; Ma, 1999; Sovchik, 1996; Trice & Ogden, 1986). According to Tooke and Lindstrom (1998), mathematics anxiety originates with classroom instruction (Williams, 1988), and has been tied to poor academic performance of students, as well as to the effectiveness of elementary teachers (Bush, 1981; Hembree, 1990). Teachers with high math anxiety are more inclined to teach using traditional methods rather than conceptual methods of mathematics. They spend significantly less time, and are resistant to, implementing teaching practices that include problem solving and exploration (Karp, 1991). Teachers with math anxiety avoid teaching mathematics (Trice & Ogden, 1986) and convey their attitude to their students (Swetman, 1994). Their negative attitudes affect the performance of their students (Hembree, 1990; X. Ma, 1999). Teague and Austin-Martin argue that not only do teachers' attitudes toward mathematics affect student attitudes, but that teachers' attitudes may also jeopardize effectiveness of their instruction (as cited in Tooke & Lindstrom, 1998). This is cause for great concern as teachers who possess higher levels of mathematics anxiety may unintentionally pass on negative feelings to their students (Hembree, 1990; Scarpello, 2007; Sherman & Christian, 1999).

The vision of mathematics based on recommendations from the NCTM includes constructivist approaches that continue to impact the practices of teachers in the mathematics classroom (NCTM, 2000). Teachers are the critical component of success in mathematics education (Battista, 1994). Teacher implementation of effective instructional practices in mathematics has been linked to the level of mathematics anxiety in teachers (Bush, 1981; Karp, 1991). The researchers suggests that the presence of math anxiety demands explanation and that the simplest reasons for this anxiety result from learning experiences with math, teacher and parents attitudes toward math, and the way they instruct children in math, all of which are associated to the preparation programs and content background of teachers (Scarpello, 2007; Sherman & Christian, 1999).

Teacher Preparation Programs and Mathematics Content Background

"In this changing world, those who understand and can do mathematics will have significantly enhanced opportunities and options for shaping their futures. A lack of mathematical competence keeps those doors closed" (NCTM, 2010, p.50). Overall, teacher preparation programs for elementary certifications lack comprehensive coursework in mathematics and mathematics teaching. Therefore, many elementary teachers enter the field lacking the depth and breadth of mathematics content knowledge and confidence to effectively teach mathematics (Ball, Hill, & Bass, 2005). As of 2010, only two states had policies requiring elementary teachers to pass a mathematics content assessment. No other states require elementary teachers have a requisite level of mathematical knowledge as a component of certification assessment (National Council on Teacher Quality, 2010). In Maryland, elementary teacher certification requires a minimum of 12 semester hours of course work in both mathematics and science however, there is no requirement regarding performance on a mathematics assessment (Code of Maryland Annotated Regulations, 2014). Ball, Hill, & Bass (2005) assert that pre-service programs must include courses that address the mathematics content specific to the grade levels of teacher certification. Rech, Hartzell, and Stephens (1993) compared college students majoring in elementary education to the general college population and found that elementary education majors had poorer attitudes about math and decreased math competence. Additionally, studies have shown that many enter the profession with math anxiety and attitudes about mathematics that are not as positive as their attitudes about other content areas (Kelly & Tomhave, 1985; Hembree, 1990).

The book, *Knowing and Teaching Elementary Mathematics* by Liping Ma (1999) compared United States elementary teachers to Chinese elementary teachers. One component of Ma's text compared answers to elementary school mathematics questions by 23 United States elementary school teachers to those by 72 Chinese elementary school mathematics teachers. Of the United States teachers, 12 were participating in a program sponsored by the National Science Foundation with a goal "to prepare excellent classroom mathematics teachers to be in-service leaders in their own school districts or regions" (L. Ma, 1999, p. 524). The other 11 United States teachers were interns with one year of teaching experience. The interns were scheduled to graduate from a Masters Degree program at the end of the summer the interviews took place. Contrastingly, most of the Chinese teachers had completed ninth grade in high school and two or three years of additional schooling. Despite fewer years of formal education, the Chinese teachers demonstrated much greater understanding of fundamental mathematics. Ma attributed the difference to the deficiencies related to content and pedagogy in U.S. elementary schools (L. Ma, 1999).

In the United States, elementary mathematics is commonly perceived as fundamental and easy to understand. Liping Ma (1999) presents data that shatters this myth. She notes "Elementary mathematics is not superficial at all, and anyone who teaches it has to study it hard in order to understand it in a comprehensive way" (p. 146). But, she concludes: "The factors that support Chinese teachers' development of their mathematical knowledge are not present in the United States. Even worse, conditions in the United States militate against the development of elementary teachers' mathematical knowledge..." (p.xxv).

Teachers need a deep understanding of the mathematics they teach: concepts, practices, principles, representations, and applications, to support effective instruction. A teacher's conceptual understanding of mathematics influences classroom instruction directly and positively. Content knowledge influences decisions teachers make about classroom instruction. Teachers with less content knowledge emphasize algorithms and procedures. Teachers with a deeper content knowledge also teach algorithms and procedures; however, they emphasize building student's conceptual understanding of the mathematics (McREL, 2010). The National Mathematics Advisory Panel Report (2008) made several recommendations pertaining to teachers and teacher education. One recommendation is that teachers must know "the mathematical content they are responsible for teaching and its connections to other important mathematics" (NMAP, 2008, p. xxxi). The panel notes it is imperative that the preparation programs for elementary teachers be strengthened, including pre-service and in-service opportunities (NMAP, 2008).

"The teacher preparation curriculum is weighted heavily with courses in education methods at the expense of courses in subjects to be taught" (United States National Commission on Excellence in Education, 1983, p. 20). A survey of teacher training institutions indicated that elementary school teacher candidates spend less than 60% of their time in subject-specific courses (United States National Commission on Excellence in Education, 1983). While K-5 teachers must participate in elementary skills-oriented courses, they should also participate in courses that require them to "explore the mathematical culture beyond basic skills" (Wu, 1997, para. 4). "Although many studies demonstrate that teachers' mathematical knowledge helps support increased student achievement, the actual nature and extent of that knowledge –whether it is simply basic skills at the grades they teach, or complex and professionally specific mathematical knowledge – is largely unknown" (Ball et al., 2005, p. 16). The lack of knowledge of elementary teachers is a significant problem that impacts math anxiety and must be addressed. "We need higher standards for selection into teacher preparation programs that include demonstrated proficiency in math … and elementary teacher programs that include more rigorous math courses in content and pedagogy" (Epstein & Miller, 2011, p.1).

Documented methods of addressing math anxiety

The NCTM maintains that by gaining competence in mathematical skills, teachers will have less anxiety about, and more success teaching, mathematics (NCTM, 2009). Most of the research on relieving math anxiety in elementary teachers focuses on pre-service teachers. Some research has proposed that there may be ways to address negative attitudes in pre-service teachers. Researchers claim that math anxiety in pre-service teachers may be reduced through ensuring that teacher's conceptual understanding of mathematical content precedes their procedural knowledge (Malinsky et al., 2006). The most practical solution to teacher math anxiety is to ensure teachers participate in an elementary mathematics methods courses and/or similar professional development opportunities. Previous research (Brady & Bowd, 2005; Gresham, 2007a; Huinker & Madison, 1997; Utley, Moseley, & Bryant, 2005) has revealed statistically significant reductions in mathematics anxiety in pre-service teachers who completed an elementary mathematics methods course.

Effective mathematics methodology courses address methodology, content, and conceptual understanding and serve to reduce mathematics anxiety (Levine, 1996; Nilssen, Gudmundsdottir, & Wangsmo-Cappelen, 1995). Some studies indicate that mathematics methods courses have been effective in reducing mathematics anxiety (Huinker & Madison, 1997; Tooke & Lindstrom, 1998). Additionally, pre-service teachers show significant improvement in their attitudes toward mathematics when their methodology courses include activities that address actual issues in mathematics (Gresham, 2007a).

Effective mathematics methods courses and professional development workshops should integrate a problem solving approach that supports conceptual understanding, mathematical reasoning, and making connections within mathematics (National Council of Teachers of Mathematics, 1989). Research indicates mathematics courses that address conceptual understanding of mathematics prior to the procedural understanding have been successful in reducing teacher math anxiety (Nilssen, Gudmundsdottir, & Wangsmo-Cappelen, 1995; Vinson, 2001). Interviews in a study by Swars suggest that teachers need experiences with mathematics courses that address past experiences with mathematics and build a self-awareness of negative experiences (2005). Addressing self-awareness may support reduction in math anxiety (Furner & Duff, 2002).

Sherman and Christian (1999) believed using a skills development approach would enhance pre-service teachers' skills and lead to mathematics success and enhanced self-concept. Therefore, they provided intervention that consisted of a mathematics methods course, which highlighted the use of manipulatives, problem solving, and cooperative learning to support teacher understanding of mathematics teaching methods. They maintained that in order to succeed in a variety of daily tasks, individuals must understand underlying numerical concepts. Sherman and Christian's (1999) research suggests that pre-service teachers who successfully complete a mathematics education course in which they directly participate, comprehend, experience hands-on lessons, discuss mathematical concepts, investigate reasoning, and are involved in problem-solving situations, will demonstrate decreased math anxiety.

Liu (2008) investigated the use of on-line discussions of anxiety toward teaching mathematics in elementary teacher candidates using a small sample of thirty-nine pre-service teachers primarily directed toward the reduction of mathematics anxiety in methods courses. After eight weeks of on-line discussion, the pre-service teachers completed a mathematics anxiety questionnaire, and their mathematics anxiety was lessened. Liu hypothesized that since mathematics anxiety is a learned behavior, it can be reduced over time. Wu (2011) notes that until undergraduate programs are changed for pre-service teachers in mathematics, mathematics education in elementary schools will continue to be a concern. He contends professional development that addresses content knowledge is imperative. Wu cites a study that most mathematics professional development in school systems is focused on pedagogy rather than content for elementary teachers. He notes, “it is time to face the fact that the need for change in the funding of in-service professional development is every bit as urgent as the need for more focus on content knowledge in the pre-service arena” (Wu, 2011, p. 382).

Research on Elementary Teacher Mathematics Anxiety

Rachel McAnallen, a former graduate student at the University of Connecticut, studied mathematics anxiety in elementary classroom teachers. Her mixed-method study “investigated mathematics anxiety in elementary teachers and whether those who experience mathematics anxiety also have professional anxiety about teaching mathematics” (McAnallen, 2010, p. 9). McAnallen’s study is one of the only studies involving math anxiety of full-time teachers working in the profession. She developed a survey instrument titled the McAnallen Anxiety in Mathematics Teaching Survey (MAMTS) (Appendix A). The MAMTS was administered to a sample of 691 elementary teachers from eight states representing rural, urban, and suburban communities. The MAMTS was designed to assess math anxiety, as well as the initial onset of math anxiety (primary elementary grades, elementary grades, middle school, or high school and beyond). One qualitative category of the study asked participants specifically about teachers and teaching practices that create math anxiety. McAnallen notes “The most common responses included comments about feelings of humiliation, ridicule, or embarrassment, the style of the teacher, instructional strategies used or not used, and the adult's lack of conceptual knowledge to teach mathematics" (McAnallen, 2010, p.44). She concluded that, overall, participant responses noted that their teachers not only lacked conceptual knowledge of mathematics, but also were not able to explain mathematical operations and did not teach challenging mathematical concepts. McAnallen (2010) asserts that future research exploring "the impact of a series of hands-on conceptually based workshops on advanced content knowledge and its relationship to anxiety in teachers of mathematics" (p. 61) should be conducted. She contends that a study of this type would enable researchers and professional developers to determine whether or not professional development helps to reduce teacher math anxiety.

Implications of the Common Core State Standards

The Common Core State Standards (CCSS) have been adopted by forty-five states. The CCSS establish standards for what students will study (CCSSI, 2012). In 1989, the NCTM stated, "Today's society expects schools to insure that all students have an opportunity to become mathematically literate, are capable of extending their learning, have an equal opportunity to learn, and become informed citizens capable of understanding issues in a technological society" (p. 3). The CCSS supports these societal expectations. The mission statement of CCSS is:

> To provide a consistent, clear understanding of what students are expected to learn, so teachers and parents know what they need to do to help them. The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers. With American students fully prepared for the future, our communities will be best positioned to compete successfully in the global economy (National

Governors Association & Council of Chief State School Officers, 2010, para. 1). The CCSS for mathematics demand more rigorous mathematics instruction in earlier grades than most state curricula have required. The focus on increased mathematical content has significant implications on the need for competent and confident elementary teachers, particularly for mathematics instruction. The CCSS for mathematics show clearly that teachers of mathematics in all grades must have much deeper content knowledge to teach mathematics effectively and that content preparation needs to be tied closely with pedagogical training. Failure to address deficits in teacher content knowledge and pedagogy could have grave implications on the implementation of the mathematics CCSS (Luce, 2012).

John Ewing, President of Math for America, contends the CCSS for mathematics require "that all school-level mathematics teachers across the country know enough mathematics to be able to understand the materials they teach in context-not just the individual pieces they are assigned to teach" (Ewing, 2010, para. 4). In a joint public statement, the NCTM, the National Council of Supervisors of Mathematics (NCSM), the Association of State Supervisors of Mathematics (ASSM), and the Association of Mathematics Teacher Educators (AMTE), emphasize the critical nature of ensuring teachers understand the CCSS and that professional development within local school systems is comprehensive. The statement claims the CCSS necessitate an increased focus on teaching and learning (NCTM, the National Council of Supervisors of Mathematics (NCSM), the Association of State Supervisors of Mathematics (ASSM), and the Association of Mathematics Teacher Educators (AMTE), 2010). Linda Gojak, president of NCTM, asserts the importance of elementary students being taught by teachers with a deep knowledge of mathematics (Gojak, 2013). Similarly, teachers note that training and experience in mathematics are essential for success in teaching the mathematics CCSS, which is comprehensively different than the previous math curricula (Bui, 2013a). According to a non-scientific survey of Maryland teachers conducted by the Maryland State Education Association, almost seventy percent of teachers surveyed maintain they are not prepared to teach the CCSS and would like more time and professional development (Bui, 2013b).

> The future success of students depends on their experiences in the early grades. If we expect young students to have a solid foundation in mathematics, they must be taught by teachers who deeply understand mathematics concepts and who are passionate about mathematics (Gojak, 2013, para. 11).

To realize the potential of the CCSS, teachers should have access to high-quality professional development, including opportunities to deeply understand the Standards for Mathematical Content and the implications for instruction of the Standards for Mathematical Practice (CCSSI, 2012b).

Chapter 3: Methodology

Purpose of Study

The purpose of this study was to determine if teachers who participate in yearlong mathematics professional development, called Year Long Math Course (YLMC), have less math anxiety than teachers who did not participate in YLMC. As previously noted, the researcher was employed by TCPS as the supervisor of prekindergarten through twelfth grade mathematics. Content supervisors in TCPS design, implement, and evaluate professional development steeped in content and pedagogy. TCPS elementary teachers have expressed apprehension regarding the content and pedagogical demands of the CCSS for mathematics. Therefore, it was prudent for the researcher to seek to evaluate the effectiveness of YLMC on alleviating math anxiety. The results of the study serve to inform future plans for professional development.

The researcher hypothesized YLMC would reduce teacher math anxiety based on the argument by NCTM that by gaining competence in mathematical skills, teachers will have less anxiety about, and more success teaching, mathematics (NCTM, 2009). YLMC is designed to strategically focus on the Common Core State Standards, the Standards for Mathematical Practice in the Common Core State Standards, development of mathematics leadership and strategies for mathematics instruction designed to build confident and competent mathematics teachers and learners. Topics for kindergarten were two critical areas: (1) representing and comparing whole numbers, initially with sets of objects; (2) describing shapes and space. Grade 1 YLMC focused on four critical areas: (1) developing understanding of addition, subtraction, and strategies for addition and subtraction within 20; (2) developing understanding of whole number relationships and place value, including grouping in tens and ones; (3) developing understanding of linear measurement and measuring lengths as iterating length units; and (4) reasoning about attributes of, and composing and decomposing geometric shapes. Grade 2 YLMC focused on four critical areas: (1) extending understanding of base-ten notation; (2) building fluency with addition and subtraction; (3) using standard units of measure; and (4) describing and analyzing shapes. Participants received direct instruction and participated in group activities to reinforce the strategies and concepts. Each session included resources and activities teachers could share with their team mates and implement in their classroom. Additional information on YLMC, including the initial information sent to principals, initial letter to participant, session focus information, and resources and materials used for the course, is provided in Appendices B-E.

The researcher conducted a quantitative study using a survey. The McAnallen Anxiety in Mathematics Teaching Survey (MAMTS) was developed by McAnallen in 2009 to facilitate data collection on personal and professional math anxiety in elementary teachers. The MAMTS was comprised of 29 items, 15 of which were related to professional math anxiety, and 14 were related to personal math anxiety (McAnallen, 2010). The researcher procured to use the MAMTS for the purpose of this study (Appendix B). The MAMTS was utilized by the researcher and titled McAnallen Anxiety in Mathematics Teaching Survey for Tyner County Public Schools (MAMTS-TCPS). The study evaluated whether or not participation in YLMC, steeped in mathematical content, pedagogy, participant reflection, and coaching, impacted teacher mathematics anxiety. Data from the study may be used to inform elementary mathematics professional development practices, particularly in the forty-five states implementing the

CCSS.

This chapter presents information regarding the methodology of the study: the need for research, rationale for research, conceptual framework, research questions, design of the study, description of the survey, process for the quantitative study, method of data analysis, ethical issues, and limitations of the study.

Need for research

A teacher's anxiety and attitude toward mathematics can be transmitted to students through instruction and may have a significant negative impact on their mathematical experiences and attitudes. Studies have already shown that math-anxious teachers who practice mathematics avoidance in their classrooms put their students at a significant disadvantage in mastering grade level mathematics (Hembree, 1990; Scarpello, 2007; Sherman & Christian, 1999). The implementation of the Common Core State Standards (CCSS) requires a deeper understanding of mathematical content due to the focus, coherence, and rigor integral to the design of the CCSS (CCSSI, 2012c). Focus, as it relates to the CCSS for mathematics, "means significantly narrowing the scope of content in each grade so that students achieve at higher levels and experience more deeply that which remains" (CCSSI, 2013, p. 3). Coherence is defined as "making math make sense" (CCSSI, 2013, p. 4) and making connections between similar topics within a grade and across grade levels. Finally, rigor is defined as having three aspects that must be incorporated in mathematics instruction "(1) conceptual understanding, (2) procedural skill and fluency, and (3) applications" (CCSSI, 2013, p. 5).

While math anxiety has been identified and researched since the 1950s (Dreger & Aiken, 1957), the increased attention on elementary mathematics success has brought the topic into sharp focus within elementary schools and colleges that provide undergraduate teacher preparation. School districts are feeling greater pressure to produce better student outcomes and recognize the need for well-prepared teachers. Research has indicated that while pre-service teachers may be better prepared in some content areas than others (Perry, 2004), the level of anxiety pre-service teachers experience in the content area of mathematics is significant. Studies note that not only can teacher math anxiety limit the instructional skills of teachers of mathematics, but it also may be passed on from the teacher to elementary students (Gresham, 2007a; Malinsky et al., 2006; Swars et al., 2006).

The impetus for this study was the prevalence of mathematics anxiety in college students majoring in elementary education (Kelly & Tomhave, 1985; Hembree, 1990) and the need to design professional development offerings that support reducing math anxiety and increasing mathematics content and pedagogy necessary to ensure effective teaching of the CCSS. Mathematics has been found to be increasingly important in ensuring the success of students in post-secondary education. In recent years, teacher education programs have acknowledged the existence of teacher math anxiety and the need to properly prepare teacher candidates (Brady & Bowd, 2005, Gresham, 2007a; 2007b; Malinsky et al., 2006; Sloan et al., 2002; Swars et al., 2006). Previous research (Brady & Bowd, 2005; Gresham, 2007a) has revealed statistically significant reductions in mathematics anxiety in pre-service teachers who completed a mathematics methods course. The National Mathematics Advisory Panel notes that there is a relationship between the mathematics professional development for elementary and middle school teachers and teacher effectiveness in mathematics. They state “teachers must know in detail and from a more advanced perspective the mathematics content they are responsible for teaching and the connections of the content to other important mathematics, both prior to and beyond the level they are assigned to teach" (NMAP, 2008, p. xxi).

The CCSS for mathematics requires that teachers of mathematics in all grades have much deeper content knowledge to teach mathematics effectively and that content preparation needs to be tied closely with pedagogical training. Unfortunately, for many new and veteran teachers, the combination of content and pedagogy has not occurred, and teacher math anxiety, if not properly addressed, will have grave implications on the implementation of the mathematics CCSS (Luce, 2012). In reviewing the literature, the researcher found only one study that evaluated the mathematics anxiety of practicing tenured and non-teachers (McAnallen, 2010). All other studies on teacher math anxiety were conducted on pre-service or non-tenured teachers.

Methodological research literature

The researcher used a quantitative research design based on the MAMTS-TCPS survey. Quantitative research is defined as "a means for testing objective theories by examining the relationship among variables" (Creswell, 2009, p. 4). Surveys were selected as the quantitative strategy of inquiry because "survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population" (Creswell, 2009, p. 12). Blair, Czaja, & Blair (2014) note one of the main concerns when "designing and conducting a survey is to achieve the research or other data collection objectives within available resources" (p.9). Surveys have three distinguishing characteristics. First, they are used to describe aspects of a population in a quantitative manner. Second, data are collected from people and, because people are involved, the data are subjective. Third, survey research uses a sample of the population to generalize the findings to a larger population after completion. Advantages of surveys are that they can provide demographic data to describe the sample, include a number of variables to enrich the study, and can elicit information regarding attitudes that would otherwise be difficult to measure. One disadvantage to the survey method that is relevant to this study is that biases may occur due to lack of response from the intended participants (Glascow, 2005).

The MAMTS-TCPS was administered as a post-test only. Demographic information collected through the survey was used to support data analysis in determining the similarities of the control and treatment group and seeking to establish that both groups were relatively similar demographically prior to the treatment. While pre-testing is considered an important element of research design, Campbell and Stanley (1963) assert, “it’s not actually essential” (p. 25). The researchers note that “For psychological reasons it is difficult to give up “knowing for sure” that the experimental and control groups were “equal” before the differential experimental treatment” (Campbell & Stanley, 1963, p. 25). Shadish, Cook, & Campbell (2002) note that post-test only design is one of the simplest experimental designs. However, it is difficult to conclude unanimously from studies using post-test only because of internal validity threats. They caution researchers in making conclusions that an independent variable is responsible for any variations in the dependent variable when using post-test design (Shadish, Cook, & Campbell, 2002).

Quasi-experimental research design was selected because it enables the researcher to answer the question of whether or not YLMC reduces teacher math anxiety and whether or not teachers who participate in YLMC have less math anxiety than those who do not participate (Butin, 2010). The survey was specifically designed to collect data on teacher math anxiety. The researcher also collected demographic data as a component of the survey. The independent variables were used to demonstrate the similarity of the two groups prior to YLMC. The use of independent variables "can be used, thus providing an increase in the power of the significance test very similar to that provided by a pretest" (Campbell & Stanley, 1963, p. 26).

Quasi-experimental design is used to measure a dependent variable. The variable of interest in this study was whether or not surveyed participants were in YLMC during the 2012-2013 school year or not. The major difference between experimental and quasi-experimental design is the random assignment of participants. Post-test only design was the specific category of quasi-experimental design that was used by the researcher. Post-test only design consists of administering an outcome measure to a treatment group and a comparison group. A concern is that the two groups may not have been similar prior to the treatment. As noted, demographic data was collected to ascertain whether or not the two groups were comparable prior to the treatment. YLMC participants either volunteered or were selected by the principal (this is an item on the MAMTS-TCPS).

Conceptual framework

The researcher used quasi-experimental research design with a survey, the MAMTS-TCPS, with census sampling as the strategy for inquiry (see figure 3.1

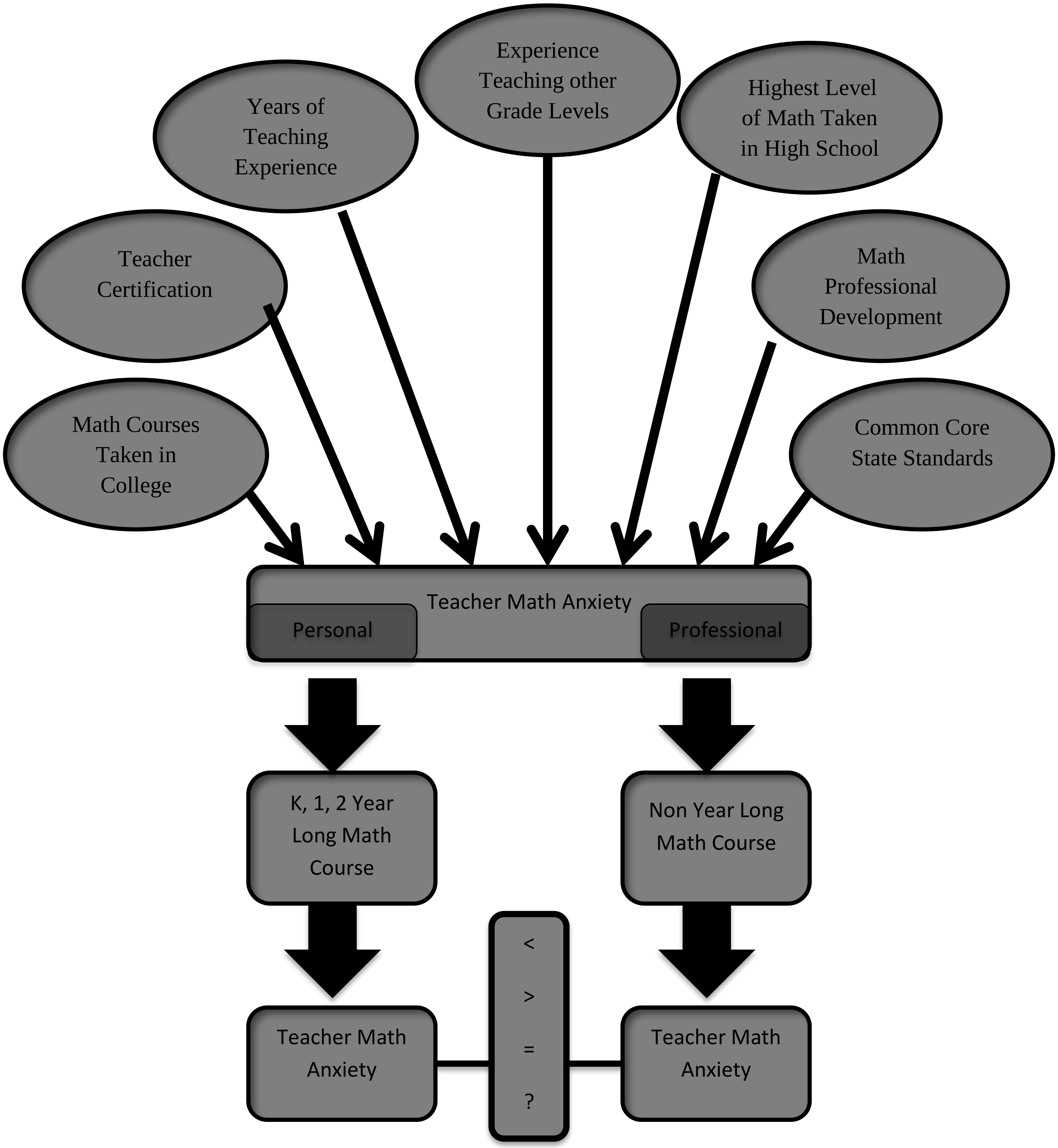


Figure 3.1. Conceptual Framework - The figure above illustrates a conceptual model of pre-existing teacher math anxiety, the CCSS for grades kindergarten, one, and two, whether or not teachers participate in YLMC, and the resulting survey-assessed teacher math anxiety. The symbols <, >, =, and ? represent the comparison of the results of the MAMTS-TCPS.

Research Question

This study sought to address the following question:

> Is there a difference between the math anxiety, as assessed using the MAMTS-TCPS, of kindergarten, first and second grade teachers who participated in the Year Long Math Course and the math anxiety of teachers teaching the same grades who did not participate in the Year Long Math Course?

MAMTS Assessment Instrument

McAnallen's initial MAMTS was 51 items to determine four factors: "personal mathematics self-efficacy, personal mathematics anxiety, mathematics teaching self-efficacy, and mathematics teaching anxiety" (McAnallen, 2010, p. 25). Her goals, specific to the MAMTS scale, as written in her research questions, were to determine

> What percentage of elementary teachers who teach mathematics in eight urban and suburban school districts report that they experience mild, moderate, or severe levels of personal mathematics anxiety? Is there a relationship between the personal mathematics anxiety factor and the mathematics professional anxiety factor on the MAMTS? To what extent can variance in elementary teachers' self reported mathematics anxiety be explained by demographic characteristics including gender, grade level taught, years of teaching experience, confidence in teaching mathematics, background in mathematics, and scores on the MAMTS? (McAnallen, 2010, p. 26)

McAnallen spent three years on development of the MAMTS "to measure mathematics anxiety and attitudes or confidence about mathematics teaching in elementary teachers" (McAnallen, 2010, p. 7). The MAMTS measures teachers' perceptions of whether they experience personal mathematics anxiety and whether they have anxiety when they teach mathematics. The development of the MAMTS began with 51 items to determine personal math self-efficacy, personal math anxiety, math teaching self-efficacy, and math teaching anxiety. A content validation scale for the pilot survey was developed and given to 12 professionals in the field to determine the validity of the 51 items. The 51 items were reduced to 40 items. A revised pilot survey using the 40 items in a 5-point Likert format was distributed to teachers attending two different conferences. Of the 900 pilot surveys distributed, 335 were returned. McAnallen then used an exploratory factor analysis (EFA) and evaluated the factors in the scale and analyzed "whether or not the variables are able to be grouped into a smaller set of underlying factors" (McAnallen, 2010, p. 26). Her analysis of data from the MAMTS determined two underlying factors of math anxiety. Factor one was professional mathematics anxiety and factor two was personal mathematics anxiety. The reliability analyses determined that the 15 items comprising professional mathematics anxiety "had a Cronbach's Alpha of .923" (McAnallen, 2010, p. 27). The 14 items comprising personal mathematics anxiety "had a Cronbach's Alpha of .952" (McAnallen, 2010, p. 27). The KMO for the scale was .965, which is considered to be outstanding. Bartlett's Test of Sphericity was used to compare the correlation matrix to the identity matrix. It was significant at the .000 level, indicating there was not an identify element. In the initial Eignenvalues, the first four items accounted for 61% of the common variance among the items and the first factor accounted for 49% of the common variance. The Scree Plot indicated one primary factor. The Pattern Matrix indicated two factors, math teaching anxiety and personal math anxiety. Ten factors were discarded because of double loadings. The final instrument had 29 items: 15 related to professional mathematics anxiety, and 14 related to personal math anxiety. The means and standard deviations for the variables are reported in table 3.1. The personal and professional subscale mean scores were found to be positively correlated (r+.63, p<.001).

Table 3.1

Means and Standard Deviations for the Variables in the MAMTS

Subscale	n	Mean	SD
Personal	682	3.53	.76
Professional	682	4.01	.52

Design of Study

McAnallen had completed a content validation scale for the pilot survey to determine the validity of the initial items on the MAMTS and reduced the items on her scale due to the results of the content validation. The MAMTS-TCPS was field tested with a total of three TCPS teachers, one from grade three, one from grade four, and one from grade five. The purpose of the field-testing is “to establish the content validity of an instrument and to improve questions, format, and scales” (Creswell, 2009, p. 150). The researcher interviewed the participants to examine their perception of the survey questions and to determine if any of the questions needed to be reworded. No items were discarded or revised as a result of the field test.

Participants/Sample

During the summer of 2012, the supervisor for mathematics at TCPS notified principals of YLMC and provided them with information on the course (Appendix C). Principals select participants by either inviting a teacher to participate or by sending the information to their teacher teams and asking for volunteers. The overarching goal of YLMC is to build teacher content knowledge and to support and build mathematics leadership. The transfer of information to grade level team mates varies from school to school based on the instructional leadership model within the elementary school, the vision and support of the principal, and the requirements of the building leadership in transferring information to other staff and teachers.

Many of the participants volunteer to take the course because they need the course credit for their certification. Many times schools want to send more than one participant for a grade level. However, because of the nature of the course, participation is limited to one teacher per grade level from each school. The course instructors are well respected in TCPS and are known for their knowledge and engaging, practical application as well as their personable nature and ability to engage and facilitate sessions in a meaningful way. YLMC participants range in age from 22 to 67 and represent small, rural schools of less than 200 students and large urban schools of greater than 900 students. The nature of the course encourages interaction of participants with one another, and they quickly form a learning community characterized by vibrant conversations and activity. Some participants are the only teacher for their grade level in their building, while others are on a team of as many as 8 other teachers in the same grade level. YLMC participants are typically eager to learn and committed to their students. Many participants stay after

YLMC for an hour or more to work further with the instructor and to discuss additional strategies for supporting students. Participants provide feedback at the end of the course through a required evaluation. In their evaluation, they note why they took the course, how much the know about the CCSS standards for mathematical practice, how much they know about the CCSS math content for their grade level as a result of the course, how the information has effected their instruction in math, changes or improvements, other comments, and how the math department can further support their knowledge of the CCSS. Participant feedback, specific to their knowledge of the CCSS for math content as a result of the course, reflected 27% reporting a beginning understanding of the content, 59% having an intermediate understanding of the content, and 14% reported complete understanding of the content.

There is no data available on the early math experiences of YLMC participants. The researcher focused solely on assessing teacher mathematics anxiety based on the MAMTS-TCPS and did not use any qualitative items designed to determine early experience in mathematics. Informal conversations with YLMC participants indicate a varied mathematics background and varied attitudes toward mathematics (as per class discussions with facilitators). This study was not designed to measure the mathematical knowledge of teachers.

The study used single-stage census sampling. Single-stage sampling is defined as "one in which the researcher has access to names in the population and can sample the people directly" (Creswell, 2009, p. 148). All kindergarten, grade one, and grade two teachers were asked to take the MAMTS-TCPS. There were 82 kindergarten teachers, 84 grade one teachers, and 80 grade two teachers. The number of participants in YLMC for the 2012-2013 school year totaled 80 teachers: 27 kindergarten teachers, 26 grade one teachers, and 27 grade two teachers. YLMC participants were included in the sample. The target response was to procure a sufficiently large sample size for analysis.

Data collection procedures

The MAMTS-TCPS (Appendix D) is an online survey that is a revision of the MAMTS and includes additional demographic items as independent variables. After receiving IRB approval, the researcher submitted a request for conducting a research study to the Superintendent of TCPS. Upon approval, the researcher emailed the link to the online survey directly to the targeted population through TCPS email. The text of the email (Appendix G) explained the purpose of the study, how results would be used, the voluntary nature of the study, the researcher's contact information, and assured respondents of their anonymity.

A multi-step approach to data collection was used to increase participant response. First, all teachers of grades kindergarten, one, and two were notified of the upcoming survey verbally at professional development offerings in August. In the third week of school, the researcher sent a note and microwave popcorn to all teachers of kindergarten, grade one and grade two through TCPS mail (Appendix H). Shortly thereafter an email (Appendix G) was sent to all potential respondents with a link to the online survey (Appendix F). A message was also posted on the TCPS math wikispaces site with a link to the online survey. Two subsequent email reminders were sent at weekly intervals. The subsequent emails contained a link to the online survey and a brief reminder of the request. The researcher began data analysis after three weeks.

Data analysis procedures

McAnallen used exploratory factor analysis (EFA) for her data analysis. EFA is "used to examine underlying factors within variables or items. It searches for patterns and correlation within the different items or variables and creates new factors out of similar variables" (AFStudeerbegeleider, 2013, para. 1). McAnallen's data resulted in two factors. She categorized factor one as professional mathematics anxiety and factor two as personal mathematics anxiety (Appendix I) (McAnallen, 2010).

The researcher hypothesized that the factors identified by the MAMTS would also be identified on the MAMTS-TCPS. Therefore, after the data were collected, the researcher first used IBM's Statistical Products and Service Solutions (SPSS) software to complete a reliability analysis to determine the Kaiser Meyer Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity to analyze the results to determine if the two factors identified by the MAMTS were also evident in the results of the MAMTS-TCPS. Next, SPSS, predictive analysis software, was used to perform an exploratory factor analysis (EFA). In this study, an EFA was used to determine if the two-factor structure for the MAMTS data set and the factor structure for the MAMTS-TCPS data set are statistically aligned. The EFA was also used to determine if the constructs for professional and personal math anxiety are valid.

A Pearson's Correlation Coefficient (PCC) was used as the next step in analyzing the data collected using the MAMTS-TCPS. The dependent variables were professional math anxiety and personal math anxiety. YLMC was the coefficient of the dummy variable for YLMC participation and non-YLMC participation. "A dummy variable was a numerical variable used in regression analysis to represent subgroups of the sample"

(Trochim, 2006, para.1). The dummy variable is the main variable of interest in this study. The errors were assumed to be normally distributed. Because independent variables were controlled in the PCC correlation, the researcher then used the data to determine if the difference between the math anxiety of YLMC participants and non-participants was statistically significant for personal and professional math anxiety.

Institutional Review Board (IRB), human subjects, and anonymity

The researcher procured approval from the University of Maryland College Park's research committee and the Human Subject Review Board. Prior to taking the online survey, participants consented to participation by reading the consent (Appendix H). The text of the consent informed participants of the purpose of the study and ensured them that their anonymity would be protected. The assurances were also iterated in the initial email, as well as in the text of the survey (Appendix F, Appendix G). Additionally, participants were fully informed of the purpose, procedures, potential risks and benefits, anonymity, participant rights, and selected whether or not they affirmed the statement of consent prior to completing the electronic survey. The consent was the first item on the survey and participants were not able to take the survey if they did not consent.

Summary of methodology

The researcher conducted a quantitative study using quasi-experimental research design to determine if teachers of grades kindergarten, one, and two who participated in TCPS YLMC during the 2012-2013 school year had less reported math anxiety than teachers who did not participate in TCPS YLMC during the 2012-2013 school year. The study was based on the results of 177 surveys of teachers of grades kindergarten, one and two. The data was analyzed using the KMO and Bartlett's Test of Sphericity to determine reliability and analyze the factors in the results. Then SPSS was used to perform a exploratory factor analysis of the MAMTS and the MAMTS-TCPS. Next, an PCC correlation model was used to compare teachers who participated in YLMC and those who did not participate, and finally a t-test was performed to determine if the difference between the math anxiety of YLMC participants and non-participants was statistically significant for personal and professional math anxiety.

Chapter 4: Findings

Overview

The purpose of this study was to evaluate math anxiety of teachers of kindergarten, first and second grade who participated in a Year Long Math Course (YLMC) to kindergarten, first and second grade teachers who did not participate in YLMC. This chapter presents the quantitative data analysis and findings in four sections: (a) introduction; (b) description of procedures used to develop and distribute the survey; (c) presentation of the quantitative data and statistical analysis of survey results; and (d) summary of the chapter.

Assessment Design and Procedures

There were two components to the administration of the survey. First, three teachers of grades 3, 4, and 5 were identified and asked to take the McAnallen Anxiety in Mathematics Teaching Survey for TCPS (MAMTS-TCPS) and then asked to discuss their results and responses with the researcher. The researcher interviewed the participants to examine their perception of the survey questions and to determine if any of the questions needed to be reworded. The second component was the administration of the survey to grades K, 1, and 2 teachers to determine their math anxiety. The study was conducted to examine the following research question:

> Is there a difference between the math anxiety, as assessed using the McAnallen Anxiety of Mathematics Teacher Survey for Tyner County Public Schools (MAMTS-TCPS), of kindergarten, first and second grade teachers who participated in Year Long Math Course (YLMC) and the math anxiety of teachers teaching the same grades in TCPS who did not participate in YLMC?

The conceptual framework articulated in chapter two of the study was used in this chapter to analyze the data collected in this study. The framework noted the different factors impacting teacher math anxiety as: number of math courses taken in college, number of math courses taken in high school, years of teaching at current grade level, years of teaching experience, current grade level taught, participation in math professional development, and the implementation of the Common Core State Standards.

The MAMTS-TCPS was used to evaluate the level of teacher professional and personal mathematics anxiety, and the data were analyzed to determine if there was a correlation between teachers who participated in the YLMC and their math anxiety. The researcher hypothesized that teachers who participated in YLMC would have less mathematics anxiety than those who did not participate in the professional development.

Participants

The survey was distributed to all current TCPS teachers of kindergarten, grade one, grade two and all teachers, regardless of current grade level taught, who participated in YLMC in the 2012-2013 school year. Two hundred forty-nine teachers received a bag of popcorn and a note from the researcher asking that they complete the survey when they received it through email. The link to the online survey was sent to the teachers two days after the popcorn and note. A reminder email with a link to the survey was sent a total of three times over the course of ten days. Of the 249 teachers who received the survey, 177 completed the survey. The response rate was 71%. Descriptive information on the participants is presented in table 4.1. Of the teachers who took the survey, 73% had between zero and seventeen years of classroom teaching experience. The distribution of teachers who took the survey by grade level was evenly distributed between grades kindergarten, grade one, and grade two, and there were two third grade teachers who took the survey. Of the two third grade teachers who took the survey, one participated in YLMC in the 2012-2013 school year and the other responded that he/she did not. Most of the teachers who took the survey reported that they took three or four math courses in high school. Sixteen of the kindergarten teachers, twenty-one of the grade one teachers, and nineteen of the grade two teachers who took the survey participated in the YLMC in 2012-2013. Disaggregated demographic data comparing respondents who did participate in YLMC and those did not participate in YLMC is presented in table 4.2. The only significant difference evidenced in the demographic data between the respondents who participated in YLMC and those who did not is the YLMC participants have participated in more TCPS professional development offerings ($t(175)=-3.473$, $p<.001$). Otherwise, the two groups are demographically similar in years as a classroom teacher, current grade level taught, years at current grade level, and number of high school courses taken.

Table 4.1

Descriptive Information of Participants

Demographic Information		N	Percent of Participants
Years as a Classroom Teacher			
0-3		32	18
4-7		41	23
8-12		40	23
13-17		34	19
18-22		12	7
>22		18	10
Current Grade Level Taught			
K		58	33
1		58	33
2		59	33
3		2	1
Current Grade Level Taught	Years at Current Grade Level		
K	0-3	21	36
	4-7	14	24
	8-12	13	22
	13-17	6	10
	18-22	2	3
	>22	2	3
1	0-3	27	47
	4-7	16	28
	8-12	9	16
	13-17	4	7
	18-22	2	3
	>22	0	0
2	0-3	24	41
	4-7	22	37
	8-12	8	14
	13-17	4	7
	18-22	1	2
	>22	0	0
3	0-3	2	100
	4-7	0	0
	8-12	0	0
	13-17	0	0
	18-22	0	0
	>22	0	0

Demographic Information		N	Percent of Participants
Participated in Math PD in 2012-2013	Grade level math PD participated in		
K	K	16	28
	1	0	0
	2	0	0
1	K	1	2
	1	17	29
	2	3	5
2	K	1	2
	1	1	2
	2	17	29
3	K		0
	1		0
	2		0
	Did not indicate	1	50
Current Grade Level Taught	Total Number of Math Courses Taken in High School		
K	1	0	0
	2	4	7
	3	20	34
	4	19	33
	5	11	19
	6	3	5
	7	0	0
1	0	1	2
	1	2	3
	2	4	7
	3	21	36
	4	17	29
	5	6	10
	6	6	10
	7	1	2
2	0	1	2
	1	1	2
	2	2	3
	3	16	27
	4	22	37
	5	13	22
	6	1	2
	7	2	3

Demographic Information		N	Percent of Participants
Current Grade Level Taught	Total Number of Math Courses Taken in High School		
3	0	0	0
	1	0	0
	2	0	0
	3	0	0
	4	1	50
	5	1	50
	6	0	0
	7	0	0
All	0	1	1
	1	3	2
	2	8	5
	3	57	32
	4	59	33
	5	31	18
	6	10	6
	7	3	2
Number of Participants who have previously participated in Tyner County Math Professional Development			
K		42	72
1		52	90
2		50	85
3		2	100
All		146	82.5

Table 4.2

Descriptive Information on YLMC Participants and non-YLMC Participants

	Participated in YLMC	N	Mean	Std. Deviation	Std. Error Mean
Current Grade Level Taught	No	120	2.00	.85	.07
	Yes	57	2.08	.82	.10
Years as a Classroom Teacher	No	120	2.90	1.41	.12
	Yes	57	3.33	1.73	.22
Years at Current Grade Level	No	120	2.03	1.17	.10
	Yes	57	2.05	1.14	.15
Total Number of Math Courses	No	120	3.76	1.24	.11
Taken in High School	Yes	57	3.85	1.07	.14
Previously Participated in TCPS	No	120	.75	.42	.03
Math Professional Development	Yes	57	.96	.18	.02

Assessment

The MAMTS-TCPS was field tested with a total of three TCPS teachers, one from grade three, one from grade four, and one from grade five. The purpose of the field-testing was to determine if there were items that needed to be revised based on the responses and discussion with the participants. The participants took the survey and then engaged in individual interviews with the researcher to discuss their perception of the survey questions and to determine if there were any revisions necessary. The participant's discussion with the researcher reflected that they clearly understood the survey questions and there was no need to make revisions.

The participants in the study were emailed a link to a 34-item survey, the MAMTS-TCPS, designed to ascertain information on personal and professional mathematics anxiety. The MAMTS-TCPS uses the scale from the McAllen Anxiety in Mathematics Teaching Survey developed by another researcher (McAnallen, 2010) in addition to additional items specific to this study. The survey took approximately two minutes to complete.

Quantitative Data

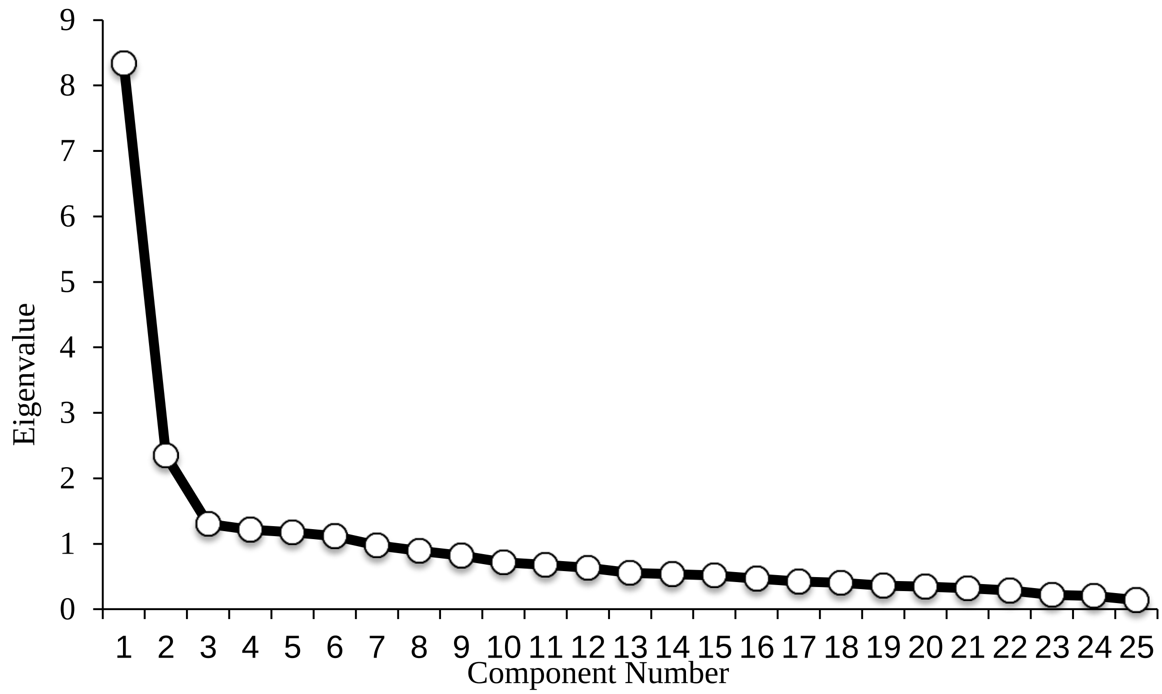
Initially, factorability of the data set for the MAMTS-TCPS was evaluated. The Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used to determine whether or not the data were suitable for factor analysis. The KMO provides a measure of sampling adequacy to determine if factor analysis is appropriate to use with the existing sample size. KMO values between 0.5 and 1.0 indicate that factor analysis is appropriate. A value close to 1 indicates that patterns of correlations are relatively compact, so factor analysis should yield distinct and reliable factors. A minimum KMO value of 0.6 is a suggested to determine that a sample is adequate for factor analysis (Field, 2013). The KMO value for this study valued .888, indicating factor analysis on the items as appropriate with principal component analysis. Bartlett's Test of Sphericity is a test statistic used to examine the hypothesis that the variables included in the test are uncorrelated (Fabrigar & Wegener, 2012). The Bartlett's Test of Sphericity was significant ($p < 0.000$) indicating correlated variables, and that factor analysis was appropriate. The chi square value for Bartlett's test of Sphericity is 1,955. Due to the chi square value being larger than 1,100, the researcher can reject the null hypothesis that the correlation matrix for the variables was an identity matrix (Field, 2013).

According to Costello and Osborne (2005) more than one criteria should be used to determine factorization of a data set. Principal component analysis was used as the extraction method. This type of analysis examines the shared variance among items and was used because it uncovers latent variables represented by the items on the MAMTS-

TCPS. Therefore, it was the most appropriate extraction method (Kahn, 2006). The initial principal component factor analysis reflected six factors with an eigenvalue greater than 1. Cattell's (1966) scree test, which graphically represents the eigenvalues for visual interpretation, total variance of the variables, and residuals (the difference between the observed and reproduced correlations) were used to determine the factorization (Costello & Osborne, 2005). Cattell (1966) suggested that the number of factors can be determined by evaluating the drop in the scree plot. The scree plot (Figure 4.1) was examined to determine the point at which variance contributed by the factors leveled off.

Figure 4.1

Scree Plot



The results of this assessment suggested a two-factor solution. Therefore, a second principal component factor analysis was run requesting a two-factor analysis. The communalities are reflected in table 4.3 and indicate the amount of common variance in each item. The extraction communalities are estimates of the variance of each variable accounted for by the factors. Values smaller than .2 may indicate that they do not align with the factor solution (UCLA: Statistical Consulting Group, 2013). An analysis of the extraction data for the communalities in this study reflects that all but two variables have values above .2. The exceptions are the item ‘I feel confident in my ability to teach mathematics to students’, which was .199, and the item ‘I would welcome the chance to have my supervisor evaluate my math teaching’ was .178.   The researcher did not drop these two items from the analysis because the factors were statistically close to .2. The communalities were evaluated, as evidenced in table 4.3

Table 4.3

Communalities

Item	Extraction
1. I was one of the best math students when I was in school.	.576
2. Having to work with fractions causes me discomfort.	353
3. I feel confident in my ability to teach mathematics to students in the grade I currently teach.	.199
4. I am confident that I can learn advanced math concepts.	503
5. When teaching mathematics, I welcome student questions.	.375
6. I have trouble finding alternative methods for teaching a mathematical concept when a student is confused.	.282
7. I can easily do math calculations in my head.	.472
8. I find it difficult to teach mathematical concepts to students.	.310
9. I feel confident using multiple resources when I teach.	.281
10. I don’t have the math background to differentiate instruction for the most	.247

Item	Extraction
talented students in my class.	
11. I dislike having to teach math every day.	.380
12. I avoided taking non-required math courses in college.	.393
13. I am confident in my math abilities.	.670
14. I am confident that I can solve math problems on my own.	.637
15. I become anxious when I have to compute percentages.	.388
16. I have math anxiety.	.691
17. It makes me nervous to think about having to do any math problem.	.604
18. On average, other teachers are probably much more capable of teaching math than I am.	.496
19. I cringe when a student asks me a math question I can't answer.	.298
20. I am comfortable working on a problem that involves algebra.	.480
21. I have strong aptitude when it comes to math.	.729
22. I doubt that I will be able to improve my math teaching ability.	.360
23. If I don't know the answer to a student's math question, I have the ability t find the answer.	372
24. I become anxious when a student finds a way to solve a problem with whi I'm not familiar	.407
25. I would welcome a chance to have the math supervisor evaluate my math teaching.	.178

Personal and professional anxiety were negatively correlated. The total variance of each solution was evaluated. Factor one accounted for 33.34% of the total variability, and factor two for 9.39% of the total variability. The two factors account for 42.73% of the variance within the 25 variables. The pattern matrix was evaluated and compared to McAnallen's results. The correlation of the two variables in this study aligned with McAnallen's findings (Appendix I). A comparison of the two variables in this study and the two variables in McAnallen's study is illustrated in table 4.4. Because the findings of the studies are aligned, the researcher named one variable personal math anxiety and one professional math anxiety. The codings were revised for the items that loaded negatively and then averaged across the items for a scale score.

Table 4.4

Items loading on the Personal and Professional Math Anxiety on the MAMTS-TCPS and the MAMTS

Item	Component		MAMTS-TCPS		MAMTS	
	1	2	Personal Math Anxiety	Professional Math Anxiety	Personal Math Anxiety	Professional Math Anxiety
I have strong aptitude when it comes to math.	.881	.053	X		X	
I was one of the best math students when I was in school.	.855	.227	X		X	
I have math anxiety.	-.852	-.040	X		X	
I am confident in my mathematical abilities.	.753	-.113	X		X	
I can easily do math calculations in my head.	.694	.014	X		X	

Item	Component 1	Component 2	MAMTS-TCPS Personal Math Anxiety	MAMTS-TCPS Professional Math Anxiety	MAMTS Personal Math Anxiety	MAMTS Professional Math Anxiety
Having to work with fractions causes me discomfort.	-.686	-.237	X		X	
It makes me nervous to think about having to do any math problem.	-.680	.160	X		X	
I become anxious when I have to compute percentages.	-.676	-.114	X		X	
I am confident that I can solve math problems on my own.	.671	-.203	X		X	
I am comfortable working on a problem that involves algebra.	.660	-.059	X		X	
I avoided taking non required math courses in college.	-.650	-.046	X		X	
I am confident that I can learn advanced math concepts.	.584	-.197	X		X	

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Item	Component 1	Component 2	MAMTS-TCPS Personal Math Anxiety	MAMTS-TCPS Professional Math Anxiety	MAMTS Personal Math Anxiety	MAMTS Professional Math Anxiety
I doubt that I will be able to improve my math teaching ability.	136	.662		X		X
When teaching mathematics I welcome student questions.	-.073	-.648		X		X
I become anxious when a student finds a way to solve a problem with which I am not familiar.	.003	.640		X		X
If I don’t know the answer to a student’s math question I have the ability to find the answer.	-.024	-.622		X		X
I have trouble finding alternative methods for teaching mathematics.	.122	.586		X		X
I feel confident using multiple resources when I teach.	-.121	-.585		X		X

Item	Component 1	Component 2	MAMTS-TCPS Personal Math Anxiety	MAMTS-TCPS Professional Math Anxiety	MAMTS Personal Math Anxiety	MAMTS Professional Math Anxiety
I find it difficult to teach mathematical concepts to students.	.040	.577		X		X
On average other teachers are probably much more capable of teaching math than I am.	-.244	.543		X		X
I would welcome the chance to have my supervisor evaluate my mathematical teaching.	-.113	-.471		X		X
I dislike having to teach math every day.	-.251	.444		X		X
I cringe when a student asks me a math question I can't answer.	-.177	.431		X		X
I feel confident in my ability to teach mathematics to students.	.028	-.431		X		X

Item	Component		MAMTS-TCPS		MAMTS	
	1	2	Personal Math Anxiety	Professional Math Anxiety	Personal Math Anxiety	Professional Math Anxiety
I don't have the math background to differentiate instruction for my students.	-.143	.406		X		X

A reliability analysis was completed to determine the Cronbach's Alpha factors. Cronbach's Alpha only tests reliability, not validity, of a scale. The results of Chronbach's Alpha support evaluation of the reliability of the two groupings of questions in the MAMTS-TCPS to determine if there are questions that are not reliable. The Chronbach's Alpha for the 12 items identified for personal math anxiety in this study is .91, indicating that the items are appropriately clustered together. The item mean is 3.43. McAnallen's study reflected a Chronbach's Alpha of .95 for personal math anxiety and item mean of 3.53. The Chronbach's Alpha for the 13 items identified for professional math anxiety was .80 with a mean of 1.92. The Chronbach's Alpha for professional math anxiety was .92 and item mean 4.01 in McAnallen's study.

The factors were compared to the two factors, personal and professional math anxiety, in McAnallen's study. The researcher reviewed the data and found that the analysis indicated the two factors in this study were consistent with McAnallen's findings (Appendix I). The researcher then ran a correlation analysis between the two factor and the demographic variables collected. Table 4.4 includes the data from these correlations. The correlation data was reviewed to determine if there was a statistically significant relationship between the variables and the factors. The researcher evaluated the correlation coefficients, analyzing the significance level. In examining the correlations it is important to remember that high scores on the personal math anxiety factor represent less personal math anxiety whereas low scores on the professional math anxiety factor represent more professional math anxiety. The study reflected only one significant correlation. Participants who took more high school courses were found, in this study, to have less personal anxiety about mathematics (r = .45, p < .001).

Finally, to test the hypothesis that participation in YLMC would reduce professional math anxiety, the researcher then ran a correlation analysis, using Pearson's Correlation Coefficient, for personal and professional math anxiety (table 4.5). The correlations between the personal math anxiety factor, the professional math anxiety factor and participation in the YLMC were examined to test the studies hypotheses. Table 4.5 indicates participation in the YLMC was unrelated to both the personal math anxiety (r = .02, p < .81) and the professional math anxiety (r = -.02, p < .77) factors. Therefore the researcher's hypotheses were not supported.

Table 4.5

Correlation Analysis for Personal and Professional Math Anxiety

Variable		Correlation factor personal math anxiety	Correlation factor professional math anxiety
Number of high school courses taken	Pearson Correlation	.450	-.116
	Sig. (2-tailed)	.000	.124
	N	177	177
Number of math methods courses in college	Pearson Correlation	.135	-.132
	Sig. (2-tailed)	.074	.081
	N	177	177
Participation in TCPS offerings	Pearson Correlation	.051	-.141
	Sig. (2-tailed)	.498	.062
	N	177	177
Grade level currently teaching	Pearson Correlation	.143	-.075
	Sig. (2-tailed)	.058	.318

Variable		Correlation factor personal math anxiety	Correlation factor professional math anxiety
	N	177	177
Number of years taught	Pearson Correlation	-.020	-.018
	Sig. (2-tailed)	.795	.809
	N	177	177
Years at current grade	Pearson Correlation	-.043	.025
	Sig. (2-tailed)	.568	.741
	N	177	177
Participated in YLMC	Pearson Correlation	.018	-.022
	Sig. (2-tailed)	.813	.772
	N	177	177

Summary

The quantitative data analysis and findings of the study were presented in this chapter. Seventy-one percent of the targeted group for the survey conducted by the researcher responded and participated in an anonymous survey, the MAMTS-TCPS, to determine if the teachers who participated in a YLMC in 2012-2013 have less professional or personal math anxiety than those who did not participate. The results indicated that teachers who participated in a YLMC in 2012-2013 did not have less professional or personal math anxiety than those who did not participate. However, teachers who took more math courses in high school had less personal math anxiety than teachers who took fewer math courses in high school. Chapter five is comprised of the conclusions and recommendations of the researcher based on the results of the study.

Chapter 5: Discussion, Conclusions, and Implications

Introduction

The purpose of this research was to determine whether or not the Year Long Math Course (YLMC) reduces teacher math anxiety. The study used a survey developed by another researcher for a similar purpose. The procedure for this study was for participants to respond to a 33 item online survey. The data from the survey was analyzed using SPSS to examine the factor structure of the mathematics anxiety instrument and then correlated to determine the relationship among the variables of interest.

There are four sections in this chapter. First, the purpose of the study, hypothesis, methodology, and data analysis will be reviewed. The conclusions comprise the second section, followed by recommendations for future practice based on the findings. Finally, the researcher will suggest opportunities for future research.

Research Question

Is there a difference between the math anxiety, as assessed using the McAnallen Anxiety

of Mathematics Teacher Survey for Tyner County Public Schools (MAMTS-TCPS), of kindergarten, first and second grade teachers who participated in the Year Long Math Course (YLMC) and the math anxiety of teachers teaching the same grades who did not participate in YLMC?

Hypothesis

The researcher hypothesized that there would be a difference between the math anxiety of those teachers who had participated in YLMC and those who had not.

Methodology

A quantitative study was conducted using a quasi-experimental research design to determine if teachers of kindergarten, grade one and grade two who participate in YLMC have less teacher math anxiety than those who did not participate.

Data Analysis

Data analysis for this study reflected only one variable examined had a significant correlation with personal math anxiety. Participants who took more high school mathematics courses reported less personal anxiety about mathematics ($r = .45$, $p < .001$). None of the variables examined was significantly correlated to professional math anxiety. The data reflected participation in YLMC was unrelated to both the personal math anxiety ($r = .02$, $p < .81$) and the professional math anxiety ($r = -.02$, $p < .77$) factors on the MAMTS-TCPS.

The one significant finding was that the number of high school math courses the subjects took impacted math anxiety. The hypothesis of this study was not supported because participation in YLMC was not found to be correlated to either personal or professional math anxiety. The variables that were not significantly correlated to personal or professional math anxiety were: number of math methods courses taken in college, participation in county math professional development, grade level currently teaching, number of years taught, years at current grade, and participation in YLMC.

Conclusions

There are two factors grounded in research that could contribute to an explanation of the lack of relationship between participation in YLMC and reduction in personal or professional math anxiety. The first factor that may have contributed to the lack of evaluated impact of YLMC on the math anxiety of the participants was the structure of the YLMC. The National Council for Teachers of Mathematics (NCTM) maintains that by gaining competence in mathematical skills, teachers will have less anxiety about, and more success in teaching, mathematics (National Council for Teachers of Mathematics (NCTM), 2009). The researcher hypothesized that because YLMC focused on increased competence in mathematical skills and knowledge, teacher math anxiety would be reduced. YLMC was a yearlong course that met once a month for 2 hours and included follow-up from the instructor, as well as assignments for participants. There were two instructors that facilitated the sessions for 80 teachers in 27 schools. YLMC met for a total of 20 hours over the course of 10 months, with an additional 10 hours of required coursework outside of class. The facilitators are central-office based staff, and while they did provide follow up and support through email, review and feedback of participant journals, and classroom visits, they are not able to ensure that their work with all participants is consistently job-embedded, ongoing, and intense. Additionally, YLMC supports the county vision of mathematics instruction. However, the development of school improvement goals is not monitored by the math department, and therefore, there is no assurance that there are school improvement goals specific to mathematics instruction. Finally, one articulated purpose of YLMC is to foster collaborative conversations and build math leadership in each school and grade level. The leadership and structure of each school must support collaboration, the YLMC participant must be willing to lead, share, and foster collaborative relationships wthin their grade level team, and there must be time alloted specifically for mathematics collaboration.

Literature on professional development indicated that to be successful and positively impact student learning, professional development must be: job-embedded, ongoing, coherent, and intense; facilitated through multiple sessions over the course of at least 6 months to a year; focused on content and effective teaching; aligned with school improvement goals; designed to foster staff collaboration; and include significant amounts of structured and sustained follow-up and support after the main professional development activities (Darling-Hammond & Richardson, 2009; Guskey & Suk Yoon, 2009). The National Mathematics Advisory Panel (2008) asserted that improvements in mathematics education must be addressed systemically through a coordinated effort of all stakeholders including central office executive staff, mathematics supervisor, curriculum specialists, building level administrators, teachers, and board members. Research indicated that teachers improve their content and pedagogy when they have the opportunity to work together, reflect, and collaborate with their colleagues and curricular coaches (Brown & Smith, 1997; Putnam & Borko, 2000; Smith, 2000). Multiple reports and studies have recommended that elementary schools hire elementary math specialists to be present in the school to provide professional development, coaching, feedback, and support in developing and supporting the content knowledge and pedagogy of elementary teachers (NCTM, 2000; NMAP, 2008; National Research Council, 2007). The NCTM asserts that it is imperative to have math specialists in each building to support teachers on a daily basis, whether it be conversations, focused seminars, model lessons, planning, or professional development (2000). In the district of this study, the only math specialists were the two instructors. A requirement for the course was that participants foster collaboration in their grade level teams, share information, and support their teammates in their math instruction. However, without focused building-level administrative and/or math specialist support, the follow-up was neither consistent nor sufficient in every building. Similarly, for YLMC to be more effective, school principals would have to be required to include school-level goals aligned with the goals of YLMC in their school improvement plans. The *NCTM Task Force on Teacher Preparation, Certification, and Shortage* noted a concern regarding the lack of support and assistance at the school level for follow-up on professional development. They noted that teacher study groups have great potential to support teachers in their math focus, but that teachers must meet regularly to discuss mathematics teaching and learning (NCTM, 2005). Similarly NCTM (2000) noted that in countries where time is allotted during the work day for teachers to meet together to analyze lessons, plan, and to teach lessons with their colleagues watching, then revise the lessons, evaluate, reflect, and share the results in written form, the practice of ongoing analysis is inherent to teaching and collaboration with colleagues is essential.

> Although this level of professional collaboration may be hard for U.S. teachers to imagine within the constraints of prevailing professional cultures and system, it illustrates the potential power of learning communities to improve mathematics teaching and learning. Finding ways to establish such communities should be a primary goal for schools and districts that are serious about improving mathematics education (NCTM, 2000, p. 371).

In the study completed by McAnallen (2010), the researcher evaluated math anxiety in elementary teachers. One of the major findings of that study in regards to their professional math anxiety was that teachers had “developed math anxiety due to negative experience from poor teaching practices and styles when they were students" (p. 58). As a result, those teachers took less rigorous mathematics courses in high school. McAnallen (2010) concluded that the "lack of rigorous academic preparation in mathematics may negatively affect elementary teacher's attitudes toward teaching in the domain" (p. 58). McAnallen's analysis of the data collected for her study reflected that, as the level of high school mathematics classes taken increased, the professional attitudes of teachers toward mathematics improved. Contrastingly, McAnallen's study found that, in regards to personal attitudes toward mathematics, teachers of intermediate grades who took higher levels of high school mathematics demonstrated more negative personal attitudes toward teaching mathematics (McAnallen, 2010).

The current study did not survey teachers as to when their math anxiety began. McAnallen concluded that the professional math anxiety of participants was directly correlated to negative learning experiences as students, which resulted in their lack of advanced high school mathematics coursework. Similarly, this study concluded that the personal math anxiety of teachers was correlated to the level of mathematics coursework they completed in high school. Her conclusion regarding the lack of advanced high school coursework negatively impacting elementary teacher's attitudes toward mathematics was aligned with the conclusion of this study. This study did not survey teachers of intermediate grades and, therefore, a correlation to the second finding was not found.

The second factor that may have contributed to the results of this study, and the fact that the study concluded that only high school mathematics courses taken were correlated with personal math anxiety, was the early experience with mathematics of each of the teacher's surveyed. Research notes that the early years of a child's education were a predictor of success in future learning in all contents (Stevenson & Newman, 1986). In their research, Clements and Sarama (2009) noted that math thinking and problem solving was cognitively foundational and that success in mathematics was strongly predicted by children's early knowledge of math. Studies have also shown that preschool math knowledge was a strong predictor of success in high school mathematics (National Mathematics Advisory Panel, 2008; National Research Council, 2009; Stevenson & Newman, 1986). Unfortunately, in the United States, many children do not have high quality preschool experiences in mathematics. Clements and Sarama (2009) found that high quality math education in preschool and early years created an opportunity for sound math learning and problem solving that builds on math competencies and sets students up for future success in math. Geary (2013) conducted research that concluded that the primary factor in predicting student success in mathematics in middle school and beyond was having an understanding of numbers prior to entering first grade. He concluded that knowledge of the number system is more important than intelligence, race, or income in regards to math success. The quality of preschool math education in the United States varies. A study by Trudge and Doucet (2004), found that, in 180 observations, only 40% of three year olds had formal experience with math. Other studies reflect that the amount of time devoted to mathematics in preschool was minimal. In one school day, sometimes only 58 seconds was devoted to mathematics and many children either lost mathematics competence or remained the same in their math performance over the course of a year (Farran & Hofer, 2013; Clements, Sarama, & DiBiase, 2004). Clements and Sarama (2009) stated that teachers often used puzzles, games, and songs, or embedded the content of math in a reading activity. The National Research Council (2009) asserted that this approach was not effective.

Teachers of primary grades should have a sound understanding of the content of math as well as pedagogy. Overall, teacher preparation programs for elementary certifications lack comprehensive coursework in mathematics and mathematics teaching. Therefore, many elementary teachers enter the field lacking the depth and breadth of mathematics content knowledge and confidence to effectively teach mathematics (Ball, Hill, & Bass, 2005). Pre-service and in-service teachers often lack an understanding of math concepts and procedures, how math knowledge is interconnected and connected to the real world, and how students' knowledge of math develops. As of 2010, only two states had policies requiring elementary teachers to pass a mathematics content assessment. No other states require elementary teachers have a requisite level of mathematical knowledge as a component of certification assessment (National Council on Teacher Quality, 2010). In Maryland, elementary teacher certification requires a minimum of 12 semester hours of course work in both mathematics and science however, there is no requirement regarding performance on a mathematics assessment (Code of Maryland Annotated Regulations, 2014). If preschool and primary students don't experience high quality mathematics instruction, they will be less inclined to be successful and less likely to take more advanced mathematics in high school (Rouse, Brooks-Gunn, & McLanahan, 2005). Research on the relationship between teacher's mathematical knowledge and student's achievement confirms the importance of teacher's content knowledge (Hill, Rowan, & Ball, 2005). Based on a review of research regarding success in high school mathematics, ensuring sound primary math education should result in more students taking high school mathematics and could have a profound impact on the teaching force if there is a greater body of students graduating from high school having been more successful in mathematics.

Research on gender and math anxiety by Beilock (2010) found female first- and second-grade teachers who had high math anxiety negatively affected their student's math performance and beliefs about their own math ability. In a study of a dozen first-grade and five second-grade teachers and their students, researchers found no difference in the performance of boys and girls in math at the beginning of the year. By the end of the school year, however, girls taught by a teacher with high math anxiety started to score lower than boys in math. A recently published study noted that 92% of current elementary teachers in the United States are female (Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013). While NCTM (2005) recommended pre-service elementary teachers complete college coursework in 5 areas of mathematics (number and operations, algebra, geometry, probability, statistics), only 10 percent of elementary teachers reported having taken courses in the recommended areas (Banilower et al., 2013). When interviewed for an article in Education Week, Daniel Ansari, the principal investigator for the Numerical Cognition Laboratory at the University of Western Ontario, in London, Ontario, stated, "Teacher math anxiety is really an epidemic. I think a lot of people go into elementary teaching because they don't want to teach high school math or science" (Sparks, 2011, para. 9). Teacher preparation programs for elementary certifications lack comprehensive coursework in mathematics and mathematics teaching. Many elementary teachers enter the field lacking the depth and breadth of math content knowledge and confidence to effectively teach mathematics. Children's motivation and success in mathematics have been greatly influenced by their teacher's attitude. The NCTM maintains that by gaining competence in mathematical skills, teachers will have less anxiety about, and more success teaching, mathematics (NCTM, 2009).

Limitations

The validity of this study may be impacted by several factors. The researcher was the supervisor of mathematics for the district where teachers were surveyed. While the survey was anonymous, the participants were made aware that the researcher was the supervisor and consequently, it could have impacted their response. Self-report is a validity threat often associated with the survey method. (Donaldson & Grant-Vallone, 2002). Researchers (Gall, Borg, & Gall, 2007) note that instrumentation, rater bias, and differential selection are also validity threats. To minimize these threats, teachers were assured of their anonymity. Teachers would be unlikely to admit to their content supervisor that they are apprehensive about teaching a subject and that they lack the content knowledge and confidence. Similarly, some teachers may have been embarrassed to admit that they experience math anxiety. Another limitation was the instrument that was used to assess math anxiety. The instrument was only used in one other study; hence there was no longitudinal history of its use.

External validity refers to how well the findings may be generalized to a population or to other settings. Because this study focused on the impact of one yearlong course on teacher math anxiety, one should exercise caution in generalizing the findings across settings and populations. The duration of the course, professional development infrastructure, presence of math coaches or curricular support, and the ratio of math curricular staff to teachers impacted the external validity.

Recommendations for Future Research

Most research on teacher math anxiety has been conducted on pre-service teachers. The implementation of the Common Core State Standards has increased the need to ensure that elementary teachers have a deep conceptual and procedural understanding of the mathematics they teach. It would benefit the education community to explore research topics on the structure of professional development and how much follow-up is incorporated in the professional development at the school level. In the district used for this study, two content specialists facilitated the elementary professional development for 27 schools. The district for this study did not have math content specialists in elementary schools.

The focus, coherence, and rigor of the Common Core State Standards for mathematics was intended to support U.S. students in preparing for a competitive international job market. It is imperative that elementary math teachers are able to grow in their content and pedagogy in an effort to deepen their knowledge and reduce math anxiety. One future research topic that maybe beneficial to this field of research evaluating the effectiveness of professional development delivered through central office staff without school-based staff to support follow-up compared with professional development delivered through central office staff with school-based staff to support and follow-up. Another research topic that may be beneficial would be research on the effectiveness of school-based staff or instructional coaches who facilitate job-embedded professional development. In 1995, The NCTM developed suggestions to help reduce anxiety in the mathematics classroom. Those practices were: accommodate different learning styles, create a variety of testing environments, design experiences so that students feel positive about themselves, remove the importance of ego, emphasize that everyone makes mistakes, make math relevant, empower students by letting them have input into their own evaluations, allow for different social approaches, emphasize the importance of original thinking rather than manipulation of formulas, and characterize math as being a human endeavor. Research that evaluates implementation of the practices identified by the NCTM would also be beneficial to this body of research.

Summary

The implementation of the Common Core State Standards requires that teachers have the mathematical knowledge to teach students new, more rigorous content, and the pedagogical knowledge to engage students in more challenging work in the classroom that builds the conceptual understanding of the students so that they understand the procedures in mathematics. To help students acquire higher-level knowledge and skills, teachers may need to improve their own content knowledge and reduce personal and professional math anxiety. The results of this study indicate that teachers who took more mathematics courses in high school have less personal anxiety toward mathematics. Research that incorporates surveys and structured interviews or additional questions by the researcher (optimally someone who has no vested interest in the school system or teachers who are involved in the research) would be beneficial to enlighten professional development practices and address teacher math anxiety, content, and pedagogical knowledge. Additionally, because conventional methods of preparation and professional development of educators does not focus on improving knowledge of content in a way that improves students' learning, K-12 and postsecondary education leaders should work cooperatively to identify strategies to improve preparation and professional development of educators.

Appendix A

Permission to Use and Revise the McAnallen Anxiety in Mathematics Teaching Survey (MAMTS)

From: RMATHMANIA@aol.com
Date: Thu, 27 Jun 2013 09:36:13 -0400
Subject: Re: MAMTS Survey
To: wrenskk@hotmail.com

Good Morning Kara,

Thank you so much for inquiring about my math anxiety survey.

The dissertation was a mixed methods, both quantative [*sic*] and qualitative. I wanted to know when the math anxiety occurred and what caused it. Those replies from the teachers are listed at the end.

There were two factors: personal math anxiety and professional (teaching) math anxiety. Both had very high reliability that you can see if you read the dissertation.

Certainly you can use the survey and adjust it as you see fit, I would be honored, just let me see your finished product. Enjoy this ride you are taking to pursue a higher degree, it is a most satisfying but arduous journey.

Rachel aka Ms. Math

Rachel R. McAnallen, PhD
504 Chaffeeville Road
Storrs, CT 06268
720-951-2834 c
www.zoidandcompany.com

Appendix B

McAnallen Anxiety in Mathematics Teaching Survey (MAMTS)

Please circle the number that best describes your level agreement with the statement.

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I was one of the best math students when I was in school.					
2. Having to work with fractions causes me discomfort.					
3. I feel confident in my ability to teach mathematics to students in the grade I currently teach.					
4. I am confident that I can learn advanced math concepts.					
5. When teaching mathematics, I welcome student questions.					
6. I have trouble finding alternative methods for teaching a mathematical concept when a student is confused.					

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
7. I can easily do math calculations in my head.					
8. I find it difficult to teach mathematical concepts to students.					
9. I feel confident using multiple resources when I teach.					
10. I don’t have the math background to differentiate instruction for the most talented students in my class.					
11. I dislike having to teach math every day.					
12. I avoided taking non-required math courses in college.					
13. I am confident in my math abilities.					
14. I am confident that I can solve math problems on my own.					
15. I become anxious when I have to compute percentages.					

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
16. I have math anxiety.					
17. It makes me nervous to think about having to do any math problem.					
18. On average, other teachers are probably much more capable of teaching math than I am.					
19. I cringe when a student asks me a math question I can't answer.					
20. I am comfortable working on a problem that involves algebra.					
21. I have strong aptitude when it comes to math.					
22. I doubt that I will be able to improve my math teaching ability.					
23. If I don't know the answer to a student's math question, I have the ability to find the answer.					

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
24. I become anxious when a student finds a way to solve a problem with which I am not familiar.					
25. I would welcome a chance to have the math supervisor evaluate my math teaching.					

26. I am a: Male Female

27. Number of years mathematics teaching experience _________
Current grade level teaching ________
Highest grade level taught _______

28. Place a check mark in front of the following math classes you successfully completed in high school:
______ Algebra I ______ Geometry ______Algebra II
______ Trigonometry/Precalculus ______ Calculus I ______ Calculus II

29. What is the highest level math class that you passed in college?
____

30. Compare yourself to other elementary teachers in terms of your mathematical abilities:

1	2	3	4	5	6	7
One of the worst	Way below average	Below average	Average	Above average	Way above average	One of the best

31. Do you enjoy doing math?
Yes
No- Skip to question 34

32. When did you first realize that you enjoyed mathematics?

Primary school (K-2)	Elementary (3-5)	Middle school (6-8)
High school (9-12)	College/Adulthood	Don't remember

33. Describe what you enjoy about mathematics:

34. Do you experience "math anxiety"?
Yes
No-Please continue to end

35. Rate the degree of your math anxiety.

1-Mild	2-Moderate	3-Severe

36. When did you first experience math anxiety?

Primary school (K-2)	Elementary (3-5)	Middle school (6-8)
High school (9-12)	College/Adulthood	Don't remember

37. Please describe the circumstances that led to your first experience with math anxiety (use the back of the paper if you need more space).

Thank you for completing this survey and please return it to Rachel McAnallen.

Appendix C

Initial Information Sent to Principals

Year Long Math Course

2012-2013

Each principal may nominate one teacher from each grade to participate in the Year Long Math Course

The purpose of Year Long Math Course is to:

- Develop teacher content knowledge in Common Core content and practices.
- Develop teachers as leaders within their own schools.

Each month participants will be required to:

- Read and reflect on assigned text to build background knowledge of the CCSS content.
- Share content from monthly CCSS Transition Course with team members as well as Lead Teacher.
- Implement and reflect on best practices for mathematics instruction.

- Teachers will be eligible to receive 2 state credits if they attend all monthly sessions and complete 17.5 hours of independent study and documented math leadership. Math institute will focus on the Common Core State Standards (CCSS), standards for mathematical practice and building content knowledge to support implementation of the Common Core State Standards.
- During the Year Long Math Course, teachers will have opportunities to refine their math content knowledge while applying it directly to the content they are teaching. Teachers will be expected to gather data and artifacts to support the progress they are making. As part of the course, teachers will develop leadership skills to communicate their knowledge to colleagues in an effective manner.

Appendix D

Initial Letter to YLMC Participants

Dear

We are delighted that you will be participating in the Year Long Math Course! The course has been designed to support you in providing quality math instruction for your students as well as to develop your skills as a math leader.

Grade 1 sessions will be held on the second Tuesday of each month:

Month	Date	Room
September	7th	Summit
October	12th	Auditorium
November	9th	Summit
December	14th	Summit
January	11th	Appalachian
February	8th	Auditorium
March	8th	Appalachian
April	12th	Appalachian
May	10th	Auditorium
June	14th	Summit

We are looking forward to a great year!

Appendix E

Session Focus and Common Core State Standards for Kindergarten, Grade 1 and Grade 2 YLMC

Kindergarten		
Session	Focus	Standards
1 & 2	Number Sense Number Relationships Patterns Data Analysis	K.CC.1a Count to 10 by ones. K.CC.3a Write numbers from 0-10. K.CC.3b Represent a number of objects with a written number 0-10 (with 0 representing a count of no objects). K.CC.4 Understand the relationship between numbers and quantities; connect counting to cardinality (0-10). K.CC.4a When counting objects, say the number names in the standard order, pairing each object with one and only one number name and each number name with one and only one object. (one-to-one correspondence) K.CC.4b Understand that the last number name said tells the number of objects counted. The number of objects is the same regardless of their arrangement or the order in which they were counted. (cardinality,conservation, and stable order) K.CC.4c Understand that each successive number name refers to a quantity that is one larger. K.CC.5a Count to answer “how many?” questions about as many as 10 things arranged in a line, a rectangular array, or a circle.

Session	Focus	Standards
		K.CC.5b Count to answer "how many?" about as many as 10 things in a scattered configuration. K.CC.5c Given a number from 1–10, count out that many objects. K.CC.6 Identify whether the number of objects in one group is greater than, less than, or equal to the number of objects in another group. Include groups with up to ten objects. Using: matching strategies and counting strategies. K.G.1a Describe objects in the environment using names of shapes (square, triangle, circle, rectangle, hexagon, and octagon).
3, 4, 5	Number Relationships Geometry Fractions Measurement	K.CC.1a Count to 50 by ones. K.CC.2 Count forward (0-20) beginning from a given number within the known sequence (instead of having to begin at 1). K.CC.3a Write numbers from 0-20. K.CC.3b Represent a number of objects with a written number 0- 20 (with 0 representing a count of no objects). K.CC.4 Understand the relationship between numbers and quantities; connect counting to cardinality. K.CC.4a When counting objects, say the number names in the standard order, pairing each object with one and only one number name and each number name with one and only one object. (one-

		to-one correspondence) K.CC.4b Understand that the last number name said tells the number of objects counted. The number of objects is the same regardless of their arrangement or the order in which they were counted. (cardinality, conservation, and stable order) K.CC.4c Understand that each successive number name refers to a quantity that is one larger. K.CC.5a Count to answer "how many?" questions about as many as 20 things arranged in a line, a rectangular array, or a circle. K.CC.5b Count to answer "how many?" about as many as 10 things in a scattered configuration. K.CC.5c Given a number from 1–20, count out that many objects. K.CC.7 Compare two numbers between 1 and 10 presented as written numerals. K.NBT.1 Compose numbers from 11 to 19 into ten ones and some further ones, e.g., by using objects or drawings, and record each composition by a drawing or equation (e.g., 18 = 10 + 8). K.NBT.2 Decompose numbers from 11 to 19 into ten ones and some further ones, e.g., by using objects or drawings, and record

		each decomposition by a drawing or equation (e.g., 18 = 10 + 8). K.MD.1 Describe measurable attributes of objects, such as length or weight. Describe several measureable attributes of a single object. K.MD.2 Directly compare two objects with a measurable attribute in common, to see which object has "more of"/"less of" the attribute, and describe the difference. For example, directly compare the heights of two children and describe one child as taller/shorter. K.MD.3a Classify objects into given categories. Limit category counts to be less than or equal to 10. K.MD.3b Count the numbers of objects in each category. Limit category counts to be less than or equal to 10. K.MD.3c Sort the categories by count. Limit category counts to be less than or equal to 10. K.G.1b Describe the relative positions of these objects using terms such as above, below, beside, in front of, behind, and next to.
6 & 7	Number development 10- 20	K.CC.1a Count to 100 by ones. K.CC.1b Count to 100 by tens. K.CC.2 Count forward (0-50) beginning from a given number

	Addition & Subtraction	within the known sequence (instead of having to begin at 1). K.OA.1 Represent addition and subtraction with objects, fingers, mental images, drawings, sounds (e.g., claps), acting out situations, verbal explanations, expressions, or equations. K.OA.2a Solve addition and subtraction word problems, e.g., by using objects or drawings to represent the problem. K.OA.2b Add and subtract within 10, e.g., by using objects or drawings to represent the problem. K.OA.3 Decompose numbers less than or equal to 10 into pairs in more than one way, e.g., by using objects or drawings, and record each decomposition by a drawing or equation (e.g., 5 = 2 + 3 and 5 = 4 + 1). K.OA.4 For any number from 1 to 9, find the number that makes 10 when added to the given number, e.g., by using objects or drawings, and record the answer with a drawing or equation. K.OA.5 Fluently add and subtract within 5.
8 & 9	Algebra Patterns Function Number	K.CC.2 Count forward (0-100) beginning from a given number within the known sequence (instead of having to begin at 1). K.G.3a Correctly names shapes regardless of their

	Relationships Computation Money Statistics	orientations or overall size. K.G.3b Identify shapes, such as cubes, cones, cylinders, and sphere as three dimensional ("solid"). K.G.4a Analyze and compare two-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of sides and corners), and other attributes (e.g., having sides of equal length). K.G.4b Analyze and compare three-dimensional shapes, in different sizes and orientations, using informal language to describe their similarities, differences, parts (e.g., number of faces and corners), and other attributes (e.g., having sides of equal length). K.G.5 Model shapes in the world by building shapes from components (e.g., sticks and clay balls) and drawing shapes. K.G.6 Compose simple shapes to form larger shapes.
10	Curricular Changes for 2013-2014!	

Grade 1		
Session	Focus	Standards
1, 2	Course Overview Regular Routines for Number Sense Development Common Core Counting Verbally Comparing 2 two digit numbers Fact Philosophy, Basic Facts	1.OA.1 Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem. 1.OA.3 Apply properties of operations as strategies to add and subtract. Examples: If 8 + 3 = 11 is known, then 3 + 8 = 11 is also known. (Commutative property of addition.) To add 2 + 6 + 4, the second two numbers can be added to make a ten, so 2 + 6 + 4 = 2 + 10 = 12. (Associative property of addition.) 1.OA.4 Understand subtraction as an unknown-addend problem. For example, subtract 10 – 8 by finding the number that makes 10 when added to 8. 1.OA.5 Relate counting to addition and subtraction (e.g., by counting on 2 to add 2). 1.OA.6 Add and subtract within 20, demonstrating fluency for addition and subtraction within 10. Use strategies such as counting on; making ten (e.g., 8 + 6 = 8 + 2 + 4 = 10 + 4 = 14); decomposing a number leading to a ten (e.g., 13 – 4 = 13 – 3 – 1 = 10 – 1 = 9); using the relationship between addition and subtraction

(e.g., knowing that 8 + 4 = 12, one knows 12 – 8 = 4); and creating equivalent but easier or known sums (e.g., adding 6 +7 by creating the known equivalent 6 + 6 + 1 = 12 + 1 = 13).

1.OA.7 Understand the meaning of the equal sign, and determine if equations involving addition and subtraction are true or false. For example, which of the following equations are true and which are false? 6 = 6, 7 = 8 – 1, 5 + 2 = 2 + 5, 4 + 1 = 5 + 2.

1.NBT.1 Count to 120, starting at any number less than 120. In this range, read and write numerals and represent a number of objects with a written numeral.

1.NBT.2 Understand that the two digits of a two-digit number represent amounts of tens and ones. Understand the following as special cases:

a. 10 can be thought of as a bundle of ten ones — called a "ten."

b. The numbers from 11 to 19 are composed of a ten and one, two, three, four, five, six, seven, eight, or nine ones.

c. The numbers 10, 20, 30, 40, 50, 60, 70, 80, 90 refer to one, two, three, four, five, six, seven, eight, or nine tens (and 0 ones).

1.NBT.3 Compare two two-digit numbers based on

		meanings of the tens and ones digits, recording the results of comparisons with the symbols >, =, and <.
3, 4, 5	Inside Double Facts Doubles + 1 Facts Making Ten Facts Geometry	1.NBT.1 Count to 120, starting at any number less than 120. In this range, read and write numerals and represent a number of objects with a written numeral 1.OA.3 Apply properties of operations as strategies to add and subtract. Examples: If 8 + 3 = 11 is known, then 3 + 8 = 11 is also known. (Commutative property of addition.) To add 2 + 6 + 4, the second two numbers can be added to make a ten, so 2 + 6 + 4 = 2 + 10 = 12. (Associative property of addition.) 1.OA.6 Add and subtract within 20, demonstrating fluency for addition and subtraction within 10. Use strategies such as counting on; making ten (e.g., 8 + 6 = 8 + 2 + 4 = 10 + 4 = 14); decomposing a number leading to a ten (e.g., 13 – 4 = 13 – 3 – 1 = 10 – 1 = 9); using the relationship between addition and subtraction (e.g., knowing that 8 + 4 = 12, one knows 12 – 8 = 4); and creating equivalent but easier or known sums (e.g., adding 6 +7 by creating the known equivalent 6 + 6 + 1 = 12 + 1 = 13). 1.NBT.3 Compare two two-digit numbers based on meanings of the tens and ones digits, recording the

results of comparisons with the symbols >, =, and <.

1.NBT.4 Add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten.

1.NBT.5 Given a two-digit number, mentally find 10 more or 10 less than the number, without having to count; explain the reasoning used.

1.NBT.6 Subtract multiples of 10 in the range 10-90 from multiples of 10 in the range 10-90 (positive or zero differences), using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used.

1.G.1 Distinguish between defining attributes (e.g., triangles are closed and three-sided) versus non-

		defining attributes (e.g., color, orientation, overall size); build and draw shapes to possess defining attributes. 1.G.2 Compose two-dimensional shapes (rectangles, squares, trapexoids, triangles, half-circles, and quarter-circles) or three-dimensional shapes (cubes, right rectangylar prisms, right circular cones, and right circular sylinders) to create a composite shape, and compose new shapes from the composite shape. 1.G.3 Partition circles and rectangles into two and four equal shares, describe the shares using the words halves, fourths, and quarters, and use the phrases half of, fourth of, and quarter of. Describe the whole as two of, or four of the shares. Understand for these examples that decomposing into more equal shares creates smaller shares.
6 7	Add within 100 including adding a two digit to one digit number, and adding a two digit number and a multiple of ten	1.OA.1 Use addition and subtraction within 20 to solve word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem. 1.OA.2 Solve word problems that call for addition of three whole numbers whose sum is less than or equal

		to 20, e.g., by using objects, drawings, and equations with a symbol for the unknown number to represent the problem. 1.OA.3 Apply properties of operations as strategies to add and subtract. Examples: If 8 + 3 = 11 is known, then 3 + 8 = 11 is also known. (Commutative property of addition.) To add 2 + 6 + 4, the second two numbers can be added to make a ten, so 2 + 6 + 4 = 2 + 10 = 12 (Associative property of addition.) 1.OA.8 Determine the unknown whole number in an addition or subtraction equation relating three whole numbers. For example, determine the unknown number that makes the equation true in each of the equations 8 + ? = 11, 5 = □ – 3, 6 + 6 =□.
8 9 10	Add within 100 including adding a two digit to one digit number, and adding a two digit number and a multiple of ten Order and Compare Objects	1.MD.1 Order three objects by length; compare the lengths of two objects indirectly by using a third object. 1.MD.2 Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit to contexts where the

	by Length	object being measured is spanned by a whole number of length units with no gaps or overlaps.
	Telling Time in hours and half hours	1.MD.3 Tell and write time in hours and half-hours using analog and digital clocks.
	Organize, represent, and interpret data with up to three categories. Ask and answer questions about the total number of data points.	1.MD.4 Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another
11	Curricular Changes for 2013-2014!	

Grade 2		
Session	Content	Common Core State Standards
1 & 2	Hundreds Chart Routines Basic Facts Place Value Developing a Solid Math Block Base Ten Exploration	2.OA.2 Fluently add and subtract within 20 using mental strategies. By end of Grade 2, know from memory all sums of two one-digit numbers. 2.OA.3 Determine whether a group of objects (up to 20) has an odd or even number of members, e.g., by pairing objects or counting them by 2s; write an equation to express an even number as a sum of two equal addends. 2.NBT.9 Explain why addition and subtraction strategies work, using place value and the properties of operations. 2.NBT.1 Understand that the three digits of a three-

digit number represent amounts of hundreds, tens, and ones; e.g., 706 equals 7 hundreds, 0 tens, and 6 ones. Understand the following as special cases:

a. 100 can be thought of as a bundle of ten tens — called a "hundred."

b. The numbers 100, 200, 300, 400, 500, 600, 700, 800, 900 refer to one, two, three, four, five, six, seven, eight, or nine hundreds (and 0 tens and 0 ones).

2.NBT.2 Count within 1000; skip-count by 5s, 10s, and 100s.

2.NBT.3 Read and write numbers to 1000 using base-ten numerals, number names, and expanded form.

2.NBT.4 Compare two

		three-digit numbers based on meanings of the hundreds tens, and ones digits, using >, =, and < symbols to record the results of comparisons 2.MD.10Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to four categories. Solve simple put together, take-apart, and compare problems using information presented in a (picture graph) and bar graph.
3, 4, 5	Measurement with rulers, yardsticks, and meter sticks Recognize and draw shapes with specific attributes. Partition circles and rectangles into 2, 3, or 4 equal shares.	2.MD.1 Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes. 2.MD.2 Measure the length

of an object twice, using length units of different lengths for the two measurements; describe how the two measurements relate to the size of the unit chosen.

2.MD.3 Estimate lengths using units of inches, feet, centimeters, and meters.

2.MD.4 Measure to determine how much longer one object is than another, expressing the length difference in terms of a standard length unit. Relate addition and subtraction to length.

2.MD.9 Generate measurement data by measuring lengths of several objects to the nearest whole unit, or by making repeated measurements of the same object. Show the measurements by making a line plot, where the horizontal scale is marked off in whole-number units.

2.MD.5 Tell and write time from analog and digital clocks to the nearest five minutes, using a.m. and p.m.

2.G.1 Recognize and draw shapes having specified attributes, such as a given number of angles or a given number of equal faces. Identify triangles, quadrilaterals, pentagons, hexagons, and cubes.

2.G.3 Partition circles and rectangles into two, three, or four equal shares,

		describe the shares using the words halves, thirds, half of, a third of, etc., and describe the whole as two halves, three thirds, four fourths. Recognize that equal shares of identical wholes need not have the same shape
6 & 7	Adding within 100 using strategies based on place value, properties of operations, and /or the relationship between addition and subtraction. Mentally add and subtract 10 or 100 to a given number. Develop Number Talks as a Closure to a lesson. Add and subtract within 1000. Develop Number Talks as a Closure to a lesson. Fundamental Games to	2.OA.1 Use addition and subtraction within 100 to solve one- and two-step word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions, e.g., by using drawings and equations with a symbol for the unknown number to represent the problem. 2.NBT.8 Mentally add 10

	support flexible math computation.	or 100 to a given number 100–900, and mentally subtract 10 or 100 from a given number 100–900. 2.NBT.5 Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction. 2.MD.6 Represent whole numbers as lengths from 0 on a number line diagram with equally spaced points corresponding to the numbers 0, 1, 2, ..., and represent whole-number sums and differences within 100 on a number line diagram. 2.NBT.6 Add up to four two-digit numbers using

strategies based on place value and properties of operations.

2.MD.5 Use addition and subtraction within 100 to solve word problems involving lengths that are given in the same units, e.g., by using drawings (such as drawings of rulers) and equations with a symbol for the unknown number to represent the problem.

2.NBT.7 Add and subtract within 1000, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a

		written method. Understand that in adding or subtracting three digit numbers, one adds or subtracts hundreds and hundreds, tens and tens, ones and ones; and sometimes it is necessary to compose or decompose tens or hundreds. 2.MD.8 Solve word problems involving dollar bills, quarters, dimes, nickels, and pennies, using $ and ¢ symbols
8 & 9	Partition a rectangle into rows and columns of same size squares and count to find the total number of them. Beginning Multiplication/Division	2.OA.4 Use addition to find the total number of objects arranged in rectangular arrays with up to 5 rows and up to 5 columns; write an equation to express the total as a sum of equal addends 2.G.2 Partition a rectangle

into rows and columns of same-size squares and count to find the total number of them.

10 Curricular Changes for 2013-2014!

Appendix F

Texts and Resources for Kindergarten, Grade 1 and Grade 2 YLMC

Bachman, V. (2007). Sizing up measurement. Math Solutions.

Burnett, J. & Tickle, B. (Fundamentals K-1: Origo Education. St. Charles, MO.

Cavanaugh, M. (2002). Math to Learn: A mathematics handbook. Great Source

Clarkson, S. & Altamuro, V. (2007). Pattern blocks for grade k-3. Didax Education. Rowley, MA.

Clements, D. & Sarama, J. (2009). Learning and teaching early mathematics. Routledge

Copley, J. (2009). The young child and mathematics. National Association for the Education of Young Children. Washington.

Horne, C. & Feifer, S. (2007). Playing with math: The name of the game! School Neuropsych Press. Middletown, MD.

Irons, R. (2007). Mathematics for Young Minds: Number Origo Math

Irons, R. & Diezmann, C. (2008). Mathematics for Young Minds: Space and Shape. Origo Math

Irons, R. ( ) Mathematics for young minds: Beginning processes. Origo Math

Richarson, K. (2012) How children learn number concepts. Math Perspectives Teacher Development Center.

Richardson, K. (1999) Developing number concepts: Counting, comparing, and number. Dale Seymour Publications.

Richardson, K. (1999) Developing number concepts: Addition and subtraction. Dale Seymour Publications.

Sutton, K. (2005). Do the math. Creative Mathematics. Arcata, CA.

Sutton, K. (2009). Let's get started. Arcata, CA.

Number corner. The Math Learning Center, Salem, OR.

Richardson, K. (1999). Understanding geometry. Lummi Bay Publishing.

Van de Walle, J., Lovin, L., Karp, K, & Bay-Williams, J., (2013). Teaching student-centered mathematics: Developmentally appropriate instruction for grades pre K-2. Pearson.

20 Thinking Questions: Pattern Blocks 1-3. (2009). Wright Group/McGraw Hill.

Greenes, C., Dacey, L. & Spungin (2001). Hot math topics: about money and time

Greenes, C. & Schulman, L. (1999). Hot math topics: finding patterns and reasoning. Dale Seymour Publications.

Dacey, L. & Greenes, C. (1999). Hot math topics: number sense. Dale Seymour Publications.

Other Manipulatives and Resources

Hip-Hoppin hundred mat™ by Learning Resources Available at: http://www.learningresources.com/product/hip+hoppin--39-+hundreds+mat--8482-.do

Individual student Rekenrek's Available at: http://www.enasco.com/c/math/Math+Manipulatives/Counting+%26+Sorting/Rekenreks/?ref=breadcrumb

Diggin' those dino counters Available at: http://www.eaieducation.com/Product/531075/Diggin_Those_Dino_Counters_-_Set_of_128.aspx

Wacky n' wild animal counters Available at:http://www.eaieducation.com/Product/531076/Wacky_n_Wild_Animal_Counters_-_Set_of_120.aspx

Inchworms™ and measuring worms™ set Available at: http://www.eaieducation.com/Product/534192/Inchworms%E2%84%A2_and_Measuring_Worms%E2%84%A2_Set.aspx

Hundred board set Available at: http://www.eaieducation.com/Product/530244/Hundred_Board_Set.aspx

Ten-frame train Available at: http://www.eaieducation.com/Product/532240/Ten-Frame_Trains.aspx

Unifix 100 track Available at: http://www.didax.com/shop/productdetails.cfm/ItemNo/210832/src/214/?gclid=CJ_Xua-T1L0CFWEV7Aod43IAeQ

Appendix G

McAnallen Anxiety in Mathematics Teaching Survey for TCPS (MAMTS-TCPS)

The title of the study for this survey is: Do K, 1, 2 teachers who participated in Year Long Math Course have less teacher math anxiety than those who did not participate?

This research is being conducted by Kara Reed at the University of Maryland, College Park. You are being asked to participate in this research project because you teach kindergarten, first, or second grade in the school district and/or participated in Year Long Math Course for grades kindergarten, one, or two during the 2012-2013 school year. The purpose of this research is to determine whether or not Year Long Math Course reduces teacher math anxiety. The procedure for this study is for participants to respond to a 33 item online survey. There are no risks associated with participating in this research. There are no direct benefits from participating in this research. However, possible benefits include improved professional development practices in the future and additional professional development offerings for elementary mathematics teachers. Participation in the survey is anonymous. Participants will not be asked any information that would allow the researcher to identify them.

Your participation in this research is completely voluntary. You may choose not to take part. If you decide to take the survey, you may stop taking the survey at any time. If you decide to stop taking the survey, you will not be penalized. If you decide to stop taking part in the survey or have questions, concerns, or complaints, have questions about your rights as a research participant, or if you need to report an injury related to the research, please contact the researcher: Kara Reed, 820 Commonwealth Avenue, Hagerstown, MD. 21740, 301-766-2926.

Checking the box below indicates that you are at least 18 years of age; you have read this consent form or have had it read to you; your questions have been answered to your satisfaction, and you voluntarily agree to participate in this research study.

Section 1

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1. I was one of the best math students when I was in school.					
2. Having to work with fractions causes me discomfort.					
3. I feel confident in my ability to teach mathematics to students in the grade I currently teach.					
4. I am confident that I can learn advanced math concepts.					
5. When teaching mathematics, I welcome student questions.					
6. I have trouble finding alternative methods for teaching a					

Section 1

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
mathematical concept when a student is confused.					
7. I can easily do math calculations in my head.					
8. I find it difficult to teach mathematical concepts to students.					
9. I feel confident using multiple resources when I teach.					
10. I don’t have the math background to differentiate instruction for the most talented students in my class.					
11. I dislike having to teach math every day.					
12. I avoided taking non-required math courses in college.					
13. I am confident in my math abilities.					
14. I am confident that I can solve					

Section 1

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
math problems on my own.					
15. I become anxious when I have to compute percentages.					
16. I have math anxiety.					
17. It makes me nervous to think about having to do any math problem.					
18. On average, other teachers are probably much more capable of teaching math than I am.					
19. I cringe when a student asks me a math question I can't answer.					
20. I am comfortable working on a problem that involves algebra.					
21. I have strong aptitude when it comes to math.					
22. I doubt that I will be able to improve my math teaching ability.					
23. If I don't know the answer to a					

Section 1

Item	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
student's math question, I have the ability to find the answer.					
24. I become anxious when a student finds a way to solve a problem with which I am not familiar.					
25. I would welcome a chance to have the math supervisor evaluate my math teaching.					

Section 2

Item	Response
26. How many years have you been a classroom teacher?	0-3 4-7 8-12 13-17 18-22 >22
27. What grade do you currently teach?	K 1 2 3 4 5 other
28. How many consecutive years have you taught at this grade level?	0-3 4-7 8-12 13-17 18-22 >22
29. Did you participate in the 2012-2013 TCPS Year Long Math Course?	Yes No
If yes, for which grade	K 1 2
Which of the following best describes why you participated?	Principal invite Volunteered
Did you complete Year Long Math Course?	Yes No
30. Please note all courses you successfully completed in high school.	Alg I Geo Alg II P-Cal Trig Cal I Cal II Stat

Section 2

Item	Response					
31. How many math methods courses did you take in your college education program?	0	1	2	3	4	
32. How many TCPS math professional development offerings have you participated in over the last 3 years?	0	1	2	3	4	>4
33. How many non-TCPS math professional development offerings have you participated in over the last 3 years?	0	1	2	3	4	>4

Appendix H

Text of Initial Contact to Participants

Please consider helping me out in my research! I'm currently in school pursuing a degree and need your help! Within the next few days, you'll receive an email from me. Please review the information and complete the survey (it won't take long!). Thanks so much for your help! Kara

Appendix I

Text of email to participants

Dear Kindergarten, Grade 1, or Grade 2 Teacher,

Earlier this week you received a note in the mail from me noting you'd be receiving an email requesting that you complete a survey. This is the email! Please note, I am asking for your participation as I work to complete research for my dissertation. Your participation is completely anonymous. I designed my study because the Common Core State Standards have significant impact on the depth of math that we teach at the elementary level. I also know from my personal experience and from my research that most of the population in the U.S. suffers from math anxiety. Therefore, I wanted to look at whether or not the professional development we design as a math team helps to reduce teacher math anxiety. The purpose of my study is to evaluate teacher math anxiety of teachers of kindergarten, first and second grade who participated Year Long Math Course (YLMC) last year compared to those who did not participate in YLMC.

Please consider taking this survey. Thank you so much for your assistance and support!

Kara Reed

reedkar@TCPS.k12.md.us

301-766-2926

Appendix J

Factors Identified in the MAMTS

Personal math anxiety	Professional math anxiety
I was one of the best math students when I was in school.	I feel confident in my ability to teach. mathematics to students in the grade I currently teach.
Having to work with fractions causes me discomfort.	When teaching mathematics, I welcome student questions.
I am confident that I can learn advanced math concepts.	I have trouble finding alternative methods for teaching a mathematical concept when a student is confused.
I can easily do arithmetic calculations in my head.	I find it difficult to teach mathematical concepts to students.
I have a lot of self-confidence when it comes to mathematics.	I feel confident using a variety of resources to teach math.
I avoided taking non-required math courses in college.	I dislike having to teach math every day
I have math anxiety.	I don't have the math skills to differentiate instruction for the most talented students in my math classes.
I am confident that I can solve math problems on my own.	On average, other teachers are probably much more capable of teaching math than I am.

Personal math anxiety	Professional math anxiety
I become anxious when I have to compute percentages.	I cringe when a student asks me a math question that I can't answer.
I am comfortable working on a problem that involves algebra.	I become anxious when a student finds a way to solve a problem with which I am not familiar.
I have a strong aptitude when it comes to math.	I doubt that I will be able to improve my math teaching ability.
It makes me nervous to think about having to do any math problem.	I would welcome the changes to have the math supervisor evaluate my teaching.

References

Achieve, Inc. (2012). *The PARCC Assessment*. Retrieved from Partnership for Assessment of Readiness for College and Careers: http://www.parcconline.org/parcc-assessment

AFStudeerbegeleider. (2013). *Factor analysis*. Retrieved June 26, 2013, from SPSS Manual: http://spssmanual.com/factor_analysis.html

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185.

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., & Ridley, K.S. (2005). *Handbook of mathematical cognition.* New York, NY. Psychology Press. 315-327.

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*(1), 14-46.

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). Report of the 2012 national survey of science and mathematics education. Chapel Hill, NC: Horizon Research, Inc.

Baroody, A.J. (1998). *Fostering children's mathematical power: An investigative approach to K-8 mathematics instruction.* Mahwah, NJ: Erlbaum.

Battista, M. (1994). Teacher beliefs and the reform movement in mathematics education. *Phi Delta Kappan, 75*, 462-470.

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.

Blair, J., Czaja, R.F., & Blair, E.A. (2014). *Designing surveys: A guide to decisions and procedures.* Los Angeles, CA. Sage.

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

Brown, C. A., & Smith, M.S. (1997). Supporting the development of mathematical pedagogy. *Mathematics Teacher, 90*, 138-143.

Buhlman, B., & Young, D. (1982). On the transmission of mathematics anxiety. *Arithmetic Teacher, 30*(31), 55-56.

Bui, L. (2013, May 7). *Education.* Retrieved June 23, 2013, from The Washington Post: http://www.washingtonpost.com/local/education/2013/05/07/5f4a2b68-b727-11e2-b94c-b684dda07add_story.html

Bui, L. (2013, June 23). *Education.* Retrieved June 23, 2013, from The Washington Post: http://www.washingtonpost.com/local/education/montgomery-teachers-getting-ready-to-teach-tougher-math-curriculum-under-common-core/2013/06/19/ea9fe596-ca13-11e2-8da7-d274bc611a47_story.html

Bureau of Labor Statistics. (2011). *Monthly Labor Review.* Retrieved September 12, 2012, from Bureau of Labor Statistics: http://www.bls.gov/opub/mlr/2011/05/art1full.pdf

Burns, M. (1998). *Math: Facing an American phobia.* Sausalito, CA: Math Solutions Publications.

Bursal, M., & Panznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-180.

Bush, L. (1981). Some thoughts for teachers on mathematics anxiety. *Arithmetic Teacher, 29*(4), 37-39.

Butin, D. W. (2010). *The education dissertation: A guide for practitioner scholars.* Thousand Oaks, CA: Corwin.

Byrd, P. G. (1982). A descriptive study of mathematics anxiety: Its nature and antecedents. *Dissertation Abstracts International*, *43*(8-A), 25-83.

Campbell, D., & Stanley, J. (1963). *Experimental and quasi-experimental designs for research.* Chicago, IL: Cengage.

Cattell, R.B. (1966). The scree test for the number of factors. *Multivariate Behavioral Research*. *1*(2):245-76

Clements, D.H., & Sarama, J. (2009). *Learning and teaching early math: The Learning trajectories approach*. New York, NY: Routledge.

Clements, D.H., & Sarama, J. (2009). *Early childhood mathematics education research: Learning trajectories for young children*. New York, NY: Routledge.

Common Core State Standards Initiative. (2012). *About the Standards*. Retrieved April 14, 2013, from Common Core state Standards Initiative: http://www.corestandards.org/about-the-standards

Common Core State Standards Initiative. (2012). *Common Standards*. Retrieved April 14, 2013, from Common Core State Standards Initiative: www.corestandards.org/

Common Core State Standards Initiative. (2012). *Mathematics Home.* Retrieved June 13, 2013, from Common Core State Standards Initiative: http://www.corestandards.org/Math

Common Core State Standards Initiative. (2013). *Math Publisher's Criteria* . Retrieved April 16, 2013, from Common Core State Standards Initiative: http://www.corestandards.org/assets/Math_Publishers_Criteria_K-8_Spring%202013_FINAL.pdf

Costello, A., & Osborne, J. (2005). Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. Practical Assessment Research & Evaluation, *10*(7), 1-9.

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches.* Thousand Oaks, CA: SAGE Publications.

Darling-Hammond, L. & Richardson, N. (2009) Teacher learning: What matters? *Educational Leadership, 66*(5), 46-53.

Denton, K., & West, J. (2002). Children's reading and mathematics achievement in kindergarten and first grade. (NCES 2002125). Washington DC: National Center for Education Statistics. http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2002125

Donaldson, S. & Grant-Vallone, E. (2002). Understanding self-report bias in organizational behavior research. Journal of Business and Psychology, 17(2), 245-260.

Dossel, S. (1993). Maths anxiety. *Australian Mathematics Teacher, 49*(11), 4-8.

Dreger, R. M., & Aiken, L. R. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology*, *48*(6), 344-351.

Duren, W. (1989). *AMS History of Mathematics, Volume 2: A Century of Mathematics in America, Part II.* Retrieved April 27, 2013, from American Mathematical Society: http://www.ams.org/samplings/math-history/hmath2-index

Dutton, W.H., & Dutton, A. (1991). *Mathematics children use and understand.* Mountain View, CA: Mayfield Publishing Company.

Ellsworth, J., & Buss, A. (2000). Autobiographical stories from pre-service elementary mathematics and science students: Implications for K-16 teaching. *School Science and Mathematics*, *100*(7), 355.

Epstein, D., & Miller, R. (2011). Slow off the mark: Elementary school teaches and the crisis in science, technology, engineering, and math education. Center for American Progress. Washington, DC. http://www.americanprogress.org/issues/2011/04/pdf/stem_paper.pd

Ewing, J. (2010). The common core math standards: Implications for teacher preparation. Retrieved June 25, 2013, from The Opportunity Equation: http://opportunityequation.org/teaching-and-leadership/common-core-math-teacher-preparation

Fabrigar, L.R., & Wegener, D.T. (2012). Exploratory factor analysis: understanding statistics. New York, New York: Oxford University Press, Inc.

Farran, D.C. & Hofer, K. (2013). Evaluating the quality of early childhood education programs. In O. Saracho & B. Spodek (Eds.), *Handbook of Research on the*

Education of Young Children (pp. 426-437). New York, NY: Routledge/Taylor & Francis.

Fennema, E., & Sherman, J. (1976). Mathematics attitude scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Catalog of Selected Documents in Psychology*, *6*(2), 31.

Ferguson, R. (1986). Abstraction anxiety: A factor of mathematics anxiety. *Journal for Research in Mathematics Education, 17*, 145-150.

Field, A. (2013). Discovering Statistics Using IBM SPSS Statistics. Sage Publishers.

Fiore, G. (1999). Math-abused students: Are we prepared to teach them? *Mathematics Teacher, 92*, 403-405.

Friedman, T. (2005). *The world is flat: A brief history of the twenty-first century*. New York, NY. Farrar, Straus and Giroux.

Furner, J., & Duff, M. (2002). Equity for all students in the new millennium: Disabling math anxiety. *Interventions in School and Clinic*, *28*(2), 67-75.

Fuson, K. (2004). Pre-K to grade 2 goals and standards: Achieving 21st-century mastery for all. *Engaging young children in mathematics: Standards for early childhood mathematics education.* Mahwah, New Jersey. Lawrence Erlbaum Associates.

Gall, M. D., Borg, W. R., & Gall, J. P. (2007). An introduction to educational research. (8th ed.). New York, NY: Pearson, Allyn & Bacon.

Geary, D.C., Hoard, M.K., Nugent, L., & Bailey, D.H. (2013). Adolescents' functional numeracy is predicted by their school entry number system knowledge. PLoS ONE 8(1): e54651. doi:10.1371/journal.pone.0054651

Gerges, G. (2001). Factors influencing preservice teachers' variation in use of instructional methods: Why is teacher efficacy not a significant contributor. *Teacher Education Quarterly*, *4*, 71-87

Glasow, P. (2005, April). *Fundamentals of survey research.* Retrieved July 1, 2013, from MITRE: www.mitre.org/work/tech_papers_05/05_0638?05_0638.pdf

Glenn Commission (2000). *Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century.* Washington, D.C., U.S. Department of Education.

Gojak, L. (2013, May 8). *President's Message.* Retrieved June 13, 2013, from National Council of Teachers of Mathematics: http://www.nctm.org/about/content.aspx?id=37329

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

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

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

Gribbons, B. & Herman, J. (1997). True and quasi-experimental designs. *Practical Assessment, Research & Evaluation*, *5(*14). Retrieved July 3, 2013 from http://PAREonline.net/getvn.asp?v=5&n=14

Guskey, T.R. & Suk Yoon, K. (2009). What works in professional development? *Phi Delta Kappan*, *90*(7), 495-507.

Hadfield, O., & McNeil, K. (1994). The relationship between Myers-Briggs personality type and mathematics anxiety among preservice elementary teachers. *Journal of Instructional Psychology, 21*(41), 375-384.

Handler, J. (1990). Math anxiety in adult learning. *Adult Learning*, *1*(6), 20-23.

Harper, N., & Daane, C. (1998). Causes and reduction of math anxiety in pre-service elementary teachers. *Action in Teacher Education*, *35,* 181-188.

Haycock, K. (2001). Closing the achievement gap. *Educational Leadership*, *58*(6), 6–11.

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

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

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

Hendel, D., & Davis, S. (1978). Effectiveness of an intervention strategy for reducing mathematics anxiety. *Journal of Counseling Psychology*, *25,* 429-34.

Hill, H., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, *42*(2), 371-406.

Holmes, V. L. (2012). Depth of teachers' knowledge: Frameworks for teachers' knowledge of mathematics. *Journal of STEM Education, 13*(1), 55-71.

Huinker, D., & Madison, S. (1997). Preparing efficacious elementary teachers in science and mathematics: The influence of methods courses. *Journal of Science Teacher Education, 8*(2), 107-126.

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *Mathematics Teacher, 92*(7), 583-586.

Jones, W. (2001). Applying the psychology to the teaching of basic math: A case study. *Inquiry, 6*(2), 60-65.

Kaiser, H.F. (1960). *The application of electronic computers to factor analysis.* Educational and Psychological Measurement. *20*,141-51.

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

Kellogg, J. S., Hopko, D. R., & Ashcraft, M. H. (1999). The effects of time pressure on arithmetic performance. *Journal of Anxiety Disorders*, *13*, 591-600.

Kelly, W. P., & Tomhave, W. (1985). A study of math anxiety and math avoidance in preservice elementary teachers. *Arithmetic Teacher, 32*(5), 51-53

Klein, D. (2003). A brief history of American K-12 mathematics education in the 20th century. In J. Royer (Ed.), *Mathematical cognition: A volume in current perspectives on cognition, learning, and instruction*. 175-223. Charlotte, NC: Information Age Publishing.

Levine, S.C. (1996). Variability in anxiety for teaching mathematics among pre-service elementary school teachers enrolled in a mathematics course. *Paper presented at the annual meeting of the American Educational Research Association* . New York, NY: ERIC Document Reproduction Service.

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

Luce, T. (2012). *National Math and Science Initiative*. Retrieved April 27, 2013, from National Math and Science Initiative: http://nationalmathandscience.org

Lyons I.M., Beilock, S.L. (2012). Mathematics anxiety: Separating the math from the anxiety. *Cereb Cortex. 22*, 2102–2110.

Ma, L. (1999). *Knowing and teaching elementary mathematics.* Mahwah, NJ: Lawrence Erlbaum Associates.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, *30*(5), 520-541.

Malinsky, M., Ross, A., Pannells, T., & McJunkin, M. (2006). Math anxiety in pre-service elementary school teachers. *Education*, *127*(2), 274-279.

McAnallen, R. (2010, January). *Examining mathematics anxiety in elementary classroom teachers.* (Doctoral dissertation, University of Connecticut, Stors, CT). Retrieved April 13, 2013, from http://digitalcommons.uconn.edu/dissertations/AAI3464333

McREL. (2010). *What we know about mathematics teaching and learning.* Bloomington, IN: Solution Tree.

Mertler, C.A. & Vannatta, R.A. (2010). Advanced and multivariate statistical methods. Los Angeles, CA: Pyrczak Publishing.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics (1995). *Professional standards for teaching mathematics curriculum and evaluation standards for school mathematics*. Reston, VA: NCTM.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: NCTM.

National Council of Teachers of Mathematics. (2005). Report of the task force on teacher preparation, certification and shortage to the national council of teachers of mathematics board of directors. Reston, VA: NCTM. Retrieved February 13, 2014 from National Council of Teachers of Mathematics: http://www.nctm.org/uploadedFiles/About_NCTM/Board_and_Committess/teacher_prep.pdf

National Council of Teachers of Mathematics (NCTM), the National Council of Supervisors of Mathematics (NCSM), the Association of State Supervisors of Mathematics (ASSM), and the Association of Mathematics Teacher Educators (AMTE). (2010). *Math Teacher Education Resources.* Retrieved June 13, 2013, from Association of Mathematics Teacher Educators: http://www.amte.net/sites/all/themes/amte/resources/JointStatementonCCSS.pdf

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). Common core state standards for mathematics. *Common core standards*. Washington, DC: National Governors Association Center for Best Practices, Council of Chief State School Officers.

National Governors Association. (2011). *Realizing the potential: How governors can lead effective implementation of the common core state standards.* Washington DC: NGA Center for Best Practices.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Washington D.C.: U.S. Department of Education.

National Research Council. (2007). *Rising above the gathering storm.* Washington, DC: The National Academies Press.

National Research Council. (2009). *Mathematics in early childhood: Learning paths toward excellence and equity*. Washington, DC: The National Academies Press.

National Science Board. (2006). America's pressing challenge: Building a stronger foundation: A companion to science and engineering indicators 2006. Arlington, VA: National Science Board.

Nilssen, V., Gudmundsdottir, S., & Wangsmo-Cappelen, V. (1995). Unexpected answers: Case study of a student teacher derailing in a math lesson. *Paper presented at the annual meeting of the American Educational Research Association* . San Francisco, CA: ERIC Document Reproduction Service.

Norwood, K. (1994). The effect of instructional approach on mathematics anxiety and achievement. *School Science and Mathematics, 94*, 248-254.

Perry, A.B. (2004). Decreasing math anxiety in college students. *College Student Journal, 38*(2), 321-327.

Preis, C., & Biggs, B. (2001). Can instructors help learners overcome math anxiety? *ATEA Journal*, *28*(4), 6-10.

Putnam, R.T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher*, *29*(1): 4-15.

Rech, J., Hartzell, J., & Stephens, L. (1993). Comparisons of mathematical competencies and attitudes of elementary education majors with established norms of a general college population. *School Science and Mathematics, 93*(3), 141-145.

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

Robertson, D. (1991). A program for the math anxious at the University of Minnesota. *American Mathematical Association of Two Year Colleges*, *13*(1), 53-60.

Rouse, C., Brooks-Gunn, J., & McLanahan, S. (2005). Introducing the issue. *The Future of Children*, *15*, 5-14.

Royer, E. J. (2003). *Mathematical cognition: A volume on current perspectives on cognition, learning, and instruction.* Greenwich, CT: Information Age Publishing.

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

Schmidt, W. and Houang, W. (2012). Curricular coherence and the common core state standards for mathematics. *Educational Researcher*, *41*(8), 294-308.

Schmidt, W. H., McKnight, C. C. and Raizen., S. A. (1997). *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education.* Boston: Kluwer Academic Publishers.

Shadish, W.R., Cook, T.D., and Campbell, D.T. (2002). *Experimental and quasi-experimental designs for generalized causal inference.* Boston: Houghton Mifflin.

Sherman, H.J. & Christian, M. (1999) Mathematics attitudes and global self-concept: An investigation of the relationship. *College Student Journal*, *33*(1) 95-101.

Silva, J., & Roddick, C. (2001). Mathematics autobiographies: A window into beliefs, values, and past experiences of preservice teachers. *Academic Exchange Quarterly*, *5*(2), 101-107.

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

Smith, M. (2000). Balancing old and new: An experienced middle school teacher's learning in the context of mathematics instructional reform. *The Elementary School Journal*, *100*(4), 351–375.

Sovchik, R. J. (1996). *Teaching mathematics to children.* New York, NY: Harper Collins.

Sparks, S. (2011). 'Math anxiety' explored in studies. *Education Week 30*(31), 1-16.

STEM Education Coalition. (2010). Letter to Senate committee on commerce, science, and transportation. Washington, D.C. Retrieved November 15, 2010 from http://nstacommunities.org/stemedcoalition/wp-content/uploads/2010/05/Letter-STEM-Ed-Coalition-to-Senate-CST-on-COMPETES-Reauthorization-42.pdf

Stevenson, H.W. and Newman, R.S. (1986). Long-term prediction of achievement and attitudes in mathematics and reading. *Child Development*, *57*, 646-659.

Stuart, V. B. (2000). Math curse or math anxiety? *Teaching Children Mathematics*, *6*(5), 330-335.

Swars, S. (2005). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional Psychology, 32*(2), 139-147.

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

Swetman, D. (1994). Fourth-grade math: The beginning of the end? *Reading improvement, 31*, 173-176.

Tallerico, M. (2007, Winter). 3 Strategies for Administrators: Supporting the school-based staff developer is a matter of 1-2-3. *Journal of Staff Development, 28*(1), 42-45.

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

Tobias, S. (1990). Mathemaics anxiety: An update. *NACADA Journal, 10*, 47-50.

Tobias, S., & Weisbrod, C. (1980). Anxiety and mathematics: An update. *Harvard Educational Review, 50*, 63-70.

Tooke, D., & Lindstrom, L. (1998). Effectiveness of a mathematics methods course in reducing math anxiety of preservice elementary teachers. *School Science and Mathematics, 98*, 136-139.

Trice, A., & Ogden, E. (1986). Correlates of mathematics anxiety in first-year elementary school teachers. *Education Research Quarterly, 11*(3), 2-4.

Trochim, W. (2006). *Dummy variables*. Retrieved July 2, 2013, from Research Methods Knowledge Base: http://www.socialresearchmethods.net/kb/dummyvar.php

Trujillo, K., & Hadfield, O. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College Student Journal, 33*, 219-233.

Tudge, J. & Doucet, F. (2004). Early mathematical experiences: Observing young black and white children's everyday activities. *Early Childhood Research Quarterly*, *19*, 21-39.

UCLA: Statistical Consulting Group. (2013). *Annotated SPSS Output Factor Analysis*. Retrieved November 12, 2013, from Institute for Digital Research and Education: http://www.ats.ucla.edu/stat/spss/output/factor1.htm

United States National Commission on Excellence in Education. (1983). *A nation at risk: The imperative for educational reform: A Report to the nation and the secretary of education, United States department of education.* Washington, D.C.: The Commission.

Utley, J., Moseley, C., & Bryant, R. (2005). Relationship between science and mathematics teaching efficacy of preservice elementary teachers. *School Science and Mathematics, 105*(2), 82-88.

Van de Walle, J., Karp, K., & Bay-Williams, J. (2010). *Elementary and middle school mathematics: Teaching developmentally*. Boston, MA: Pearson.

Vinson, B. M. (2001). A comparison of pre-service teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *Early Childhood Education Journal, 29*, 89-94.

Widmer, C., & Chavez, A. (1982). Math anxiety and elementary school teachers. *Education*, *102*, 272-276.

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

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

Wood, E. F. (1988). Math anxiety and elementary teachers: What does the research tell us? *For the Learning of Mathematics, 8*, 8-13.

Wu, H. (1997). On the education of mathematics teachers. Berkely, CA. Retrieved April 27, 2013, from http://www.math.berkeley.edu/~wu/

Wu, H. (2011). The mis-education of mathematics teachers. *Notices of the AMS*, *58*(3), 372-385.

Zettle, R., & Raines, S. (2002). The relationship of trait and test anxiety with mathematics anxiety. *College Student Journal, 34,* 246-258.