Mathematics Anxiety and Mathematics Self Efficacy as Predictors of Mathematics Teaching Self Efficacy

by

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Abstract

The purpose of this multiple methods study was to investigate whether elementary mathematics teachers' mathematics anxiety and/or mathematical efficacy predict their mathematical teaching efficacy. The study included 51 practicing elementary mathematics teachers in first through sixth grade. The teachers completed the Revised Mathematics Anxiety Rating Scale, the Mathematics Self-Efficacy Scale, and the Mathematics Teaching Efficacy Beliefs Instrument. From the survey results, four teachers, two that scored low anxiety and two that scored high efficacy, were selected to participate in classroom observations and semi structured interviews. Quantitative data were analyzed using hierarchical regression. The results were paradoxical. The R^2 change indicated that mathematics anxiety and mathematics self-efficacy were both good predictors of mathematical teaching self-efficacy. However, the standardized coefficients were not statistically significant. The findings of the qualitative data suggest that elementary mathematics teachers with low anxiety and high mathematics self-efficacy do not consistently use best practices in mathematics instruction and prefer to use more traditional strategies during mathematics instruction.

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CHAPTER I. INTRODUCTION

Overview

Proficiency in mathematics is crucial for functioning in everyday life, as well as for success in our ever-changing technological society (Brown, 2014). The importance of mathematics extends beyond the academic realm. Basic arithmetic skills are required for everyday situations. Additionally, proficiency in mathematics is related to higher levels of employability (Finnie & Meng, 2006). However, with mathematical competence being such an important feature in our society today, it is interesting that mathematics is not a popular topic among Americans, and hasn't been for generations (Anderson, 2010; Manigault, 1997; National Science Board, 2006; Polya, 1957; Wallace, 2005).   Furner and Duffy (2002) reported about 7 percent of Americans have had a positive experience with mathematics from kindergarten through college, and two thirds of adults acknowledge that they have a fear of mathematics. Elementary school is considered to be the beginning of mathematics anxiety (Beilock & Willingham, 2014; Maloney & Beilock, 2012; Harper & Daane, 1998; Tobias, 2014; Uusimaki & Nason, 2004).   When elementary students experience classrooms that are teacher-centered, the mathematical content is usually taught from a procedural, rather than a conceptual stance. Students may experience negative interactions with the mathematical content because they are taught only the basic skills rather than the concepts that underlie these skills (Beilock & Willingham, 2014; Harper & Daane, 1998; Maloney & Beilock, 2012; Swars, Daane, & Giesen, 2006; Uusimaki & Nason, 2004). These negative interactions may lower the confidence in their mathematical ability, leading to students avoiding mathematics by the time they get to middle and high school (Beilock & Willingham, 2014; Harper & Daane, 1998; Maloney & Beilock, 2012; Swars, Daane, & Giesen, 2006). In fact, the majority of college graduates choose or chose not to take advanced mathematics courses because of limited or poor mathematics preparation, possibly stemming back to their elementary school years (National Science Board, 2006; Wallace, 2005). Compounding the problem, teachers' mathematics anxiety and poor mathematical self-efficacies have been found to negatively influence students' attitudes, beliefs, and perceptions in mathematics (Beilock, Guderson, Ramirez, & Levine, 2010). Mathematics anxiety is considered to be more than a dislike of mathematics (Ashcraft, 2002; Swars, Daane, & Giesen, 2006; Vinson, 2001). Mathematics anxiety has been defined as a state of discomfort that occurs when an individual is required to perform mathematically (Swars, Daane, & Giesen, 2006; Wood, 1988), or the feeling of tension, helplessness, or mental disorganization an individual has when required to manipulate numbers and shapes (Richardson & Suinn, 1972; Tobias, 1978). Mathematics anxiety can lead to a very incapacitated state of mind and develop into a more serious mathematics avoidance and mathematics phobia (Tobias, 1978). According to Brush (1981), teachers with high mathematics anxiety tend to use a more traditional approach to teaching. They focus on teaching basic skills rather than on the mathematical concepts. These teachers devote more time to seatwork and whole-class instruction and less time to problem-solving, small-group activities, and individualized instruction. Teachers that exhibit mathematics anxiety generally have a teacher-centered classroom rather than a student-centered environment and nurture a dependent atmosphere among students (Karp, 1991). Simply put, they are teaching mathematics, but not in the desired way (Trice & Ogden, 1986), and they perpetuate their negative attitude toward mathematics among their students (Swetman, 1994). Such negative attitudes toward mathematics affect student performances and student learning (Hembree, 1990; Ma, 1999, Swars, Daane, & Giesen, 2006).

A teacher's approach to classroom mathematics instruction and practices reflects a complex set of teacher attributes, including a teacher's knowledge, beliefs, and attitude of the subject or subjects he/she is teaching (Van der Sandt, 2007). Mathematics teaching self-efficacy is comprised of two facets: personal teaching efficacy and outcome expectancy (Ashton & Webb, 1982; Bandura, 1977; Enochs, Smith, & Huinker, 2000; Gibson & Dembo, 1984). Personal teaching efficacy refers to a teacher's belief in his/her ability to be effective as a teacher and enable or promote student learning (Gibson & Dembo, 1984). Outcome expectancy is defined as the belief that effective teaching can bring about student learning, regardless of external factors such as home environment or family background (Ashton, 1985; Gibson & Dembo, 1984). Research on self-efficacy and mathematics has indicated that teachers with higher mathematical self-efficacy are more likely to use standards-based mathematics teaching practices (Brown, 2005; Haney, Czerniak & Lumpe, 1996; MacGyvers, 2001, Ottmar, Rimm-Kaufman, Berry, & Larsen, 2013; Riggs & Enochs, 1990; Spidek, Givvin, Salmon, & MacGyvers, 2001). Standards-based mathematical practices place emphasis on problem solving, reasoning, making connections between mathematical topics, communicating mathematical ideas, and providing opportunities for all students to learn (National Council of Teachers of Mathematics, NCTM, 2000). Teachers with a high sense of self-efficacy work harder and persist longer, which in turn, influences student learning while those with a low sense of teacher efficacy are more likely to use teacher directed strategies (Woolfolk-Hoy, Hoy, & Davis, 2009).

Teacher Beliefs and Attitudes

While mathematics knowledge, pedagogy, and content knowledge are certainly important aspects of teaching, there are other factors that play a role in shaping teacher practice. Pajares (1992) suggested, "another perspective is required from which to better understand teacher behaviors, a perspective focusing on the things and ways that teachers believe" (p.307).

Although a great deal of research on teacher beliefs has been conducted, a single definition of beliefs is not evident in research (Pajares, 1992; Philip, 2007). Kagan (1992) described teacher beliefs as a "form of personal knowledge that is generally defined as pre or in service teachers' implicit assumptions about students, learning, classrooms, and the subject matter to be taught" (p.66). Beswick (2006) made a distinction between beliefs and attitudes by describing beliefs as non-evaluative ideas a person regards as being true while attitudes are evaluative in nature. In addition, attitudes are the "consequences of belief but there is not a one to one correspondence between beliefs and attitudes" (Beswick, 2006, p. 37).

According to Kuhs and Ball (1986), there are four distinct approaches to mathematics teaching that are associated with beliefs. A learner-focused approach indicates a belief that mathematics is a dynamic discipline that utilizes problems solving extensively. The belief that mathematics is the practice of mathematicians and that mathematics should make sense is reflected in a content-focused approach that emphasizes understanding. A third approach, content-focused emphasizing performance, is indicative of a belief that mathematics is composed of a set of rules to be memorized and mastered. Finally, a classroom-focused approach reflects a belief that mathematics is whatever is specified in the curriculum.

Researchers tend to classify teachers' mathematics beliefs into beliefs about the nature of mathematics, beliefs about mathematics teaching, and beliefs about student learning (Cooney, 2003; Ernest, 1998; Thompson, 1992). These beliefs reflect how teachers conceptualize their roles in the classroom, their choice of classroom activities, and the instructional strategies they use (Cooney, 2003; Ernest, 1998; Pajares, 1992; Thompson, 1992). Beliefs are considered central to the way teachers conceptualize and actualize their role in the mathematics classroom, and, therefore, they are integral to any efforts to improving student learning (Pajares, 1992; Thompson, 1992).

Pre-Service Teachers Attitudes and Beliefs

Pre-service teachers come to university and college programs with concepts, attitudes, and beliefs stemming from their own experiences about content area including mathematics (Fiere, 1999; Peker, 2009). If pre-service teachers come into teacher education programs with preconceived feelings and anxieties about mathematics, it may be difficult to change their attitudes (Woolfolk-Hoy & Spero, 2005). Teacher education programs provide opportunities for pre-service teachers to examine their own attitudes and feelings as well as learn how to teach in the content areas (Rakes, 2015).

Gresham (2007) and Vinson (2001) believe that pre-service teachers often underestimate the complexity of teaching and their ability to manage lesson planning and knowledge of the subject content. Since the quality of mathematics instruction in elementary school depends on the preparation of pre-service elementary teachers, it is important to try to understand the nature of the experiences of pre-service teachers so that efforts can be made to alleviate negative attitudes and beliefs before they become practicing teachers.

Mathematics Anxiety

Mathematics anxiety is not a new concept and has been well documented since the 1950s (Austin, Wadlington, & Bitner, 1992; Dutton, 1954; Dutton & Blum, 1968; Furner & Duffy, 2002; Hembree, 1990; Jackson & Leffingwell, 1999; Ma, 1999; Richardson & Suinn, 1972). Jackson and Leffingwell (1999) suggested mathematics anxiety in students can be influenced by elementary teachers personal mathematics anxiety, beginning as early as third or fourth grade. An individual's anxiety about mathematics often has led to an avoidance of the subject altogether (Hembree, 1990). Because of this, many college students choose to not take many college mathematics foundational courses (Hembree, 1990). As a result, elementary teachers' mathematical backgrounds are limited in content knowledge and mathematical experiences (Ball, Thames, & Phelps, 2008; Hill, Rowan, & Ball, 2005; Malzahn, 2002). Therefore, they are not prepared to teach mathematics due to their backgrounds and personal anxieties regarding the subject matter (Ball, Thames, & Phelps, 2008; Hill, Rowan, & Ball, 2005; Malzahn, 2002). Elementary educators have been identified not only as having a limited knowledge of mathematics, but also a limited knowledge of research in mathematics education (NRC, 2010). Elementary teachers implement only a limited number of methods and strategies for mathematical instruction (Hill, Ball, & Schilling, 2008; Hill, Rowan, &Ball, 2005). The majority of the colleges and universities within the United States were shown to require very little mathematics for students majoring in elementary education (Malzahn, 2002). More specifically, elementary education majors were identified as a largely female population, and this population was found to have the highest level of mathematics anxiety and mathematics avoidance behaviors of any college major (Bursal & Paznokas, 2006; Harper & Danne, 1998; Hembree, 1990; Trujillo & Hadfield, 1999). Beilock, Gunderson, Ramiriez, & Levine (2010) conducted a study that looked at how female teachers' mathematics anxiety affected female student achievement. They found that teachers with high mathematics anxiety negatively affected female student achievement. They further stated that the teachers with high mathematics anxiety seemed to promote the stereotype that boys are good at math and girls are not (Beilock, Gunderson, Ramiriez, & Levine, 2010).

Teacher Self-Efficacy

Self-efficacy is a term used to describe an individual's beliefs or judgments of their personal capacity to engage in certain actions (Bandura, 1977). These beliefs are not necessarily based on a person's actual competence to accomplish a task; rather, the beliefs are based on an individual's perceptions of their ability to accomplish a task (Bandura, 1977). According to Bandura (1986), beliefs influence the amount of effort an individual invests in a task and the motivation to persist in times of difficulty. These self-efficacy beliefs impact a number of behaviors that include academic achievement, career choice, athletic performance, job performance, and recovery from an illness. Bandura (1977) established that self-efficacy indicated an individual's future oriented beliefs about the level of competence he or she can have in any given situation. Teacher self-efficacy is separated into two categories, general teaching efficacy and personal teaching efficacy (Coleman, 2001). According to Coleman (2001), a teacher's general teaching efficacy conveys a personal belief that the power of teaching influences student learning. Teachers who have high teaching efficacy take responsibility for student learning. However, teachers who have a low sense of general teaching efficacy feel powerless in helping challenging or struggling students. Teachers with low teaching efficacy feel that motivation, ability level, and family influence are the key determinants in student progress, rather than teacher influence (Coleman, 2001).

Teachers' personal efficacy reflects their beliefs regarding their individual abilities to teach, manage the classroom, and effectively instruct (Muijs & Reynolds, 2002). Teachers with high personal efficacy encourage student learning through support, academic challenges, and structured, warm environments (Muijs & Reynolds, 2002). However, teachers with low personal self-efficacy avoid topics, subjects, and situations where they feel incompetent. Low personal efficacy teachers experience higher levels of stress that negatively impact classroom effectiveness (Muijs & Reynolds, 2002). Efficacious teachers exude confidence, enthusiasm, and an expectation of success that elicit enthusiasm and motivated learning from their students, and they are less likely to criticize students that give incorrect responses (Muijs & Reynolds, 2002).

Kahle (2008) emphasized that self-efficacy directs a person's choices regarding any personal skill ability, job success and attainment, and individual course selection for higher education, because these things are directed by an individual's beliefs in his or her own abilities. Kahle (2008) also noted that self-efficacy constitutes a large part of the educational setting in that it influences academic goals, motivation, effort, interest, and self-concept of students and teachers.

Mathematical Self-Efficacy

The extent to which a student believes that he/she is competent enough to perform specific tasks, referred to as self-efficacy, is particularly important given that self-efficacy has been argued to have powerful effects on achievement behavior (Bandura, 1986). Beliefs in one's efficacy can vary across academic subjects (e.g. reading vs. writing). Students with higher mathematics self-efficacy persevere longer on difficult mathematics problems and are more accurate in mathematics computations than those lower in math self-efficacy (Collins, 1982; Hoffman & Schraw, 2009). Mathematics self-efficacy is also a stronger predictor of mathematics performance than either mathematics anxiety or previous mathematics experience (Pajares & Miller, 1995) and influences mathematics performance as strongly as overall mental ability (Pajares & Kranzler, 1995). The importance of self-efficacy in academic achievement has elicited interest in specific factors that affect a student's self-efficacy beliefs. Bandura's (1997) social-cognitive theory suggested that self-efficacy is affected by one's previous performance (Chen & Zimmerman, 2007).

In a study examining efficacy development, Utley, Moseley, & Bryant, (2005) included measures of both achievement and efficacy. In particular, 51 pre-service teachers completed the Mathematics Teaching Efficacy Beliefs Scale (MTEBS) and Science Teaching Efficacy Beliefs Scale (STEBS) at the beginning and ending of their methods courses, and at the end of their student teaching. The researchers found that the pre-service teachers increased their beliefs about their ability to teach effectively by the end of their methods courses, but a slight decrease in their beliefs occurred during student teaching (Utley, Moseley, & Bryant, 2005).

In trying to understand the impact of intensive field experiences, Charalambous, Philippou, & Kyriakides (2008) examined 89 pre-service teachers' mathematics efficacy beliefs before, during, and after participating in twelve weeks of supervised teaching. The researchers found different patterns of development among pre-service teachers with different levels of initial teacher efficacy beliefs at the outset of the study. While teacher efficacy increased, those who began with the lowest levels of teacher efficacy benefitted the most.

In 2007, Swars, Hart, Smith, Smith, & Tolar reported that instruction in mathematical pedagogy improved pre-service teachers' teaching efficacy beliefs. The longitudinal study investigated the mathematics efficacy and mathematical instructional knowledge of elementary pre-service teachers who took part in a developmental teacher preparation program that included two courses in mathematics methods. Results showed participants' mathematical pedagogical and teaching efficacy beliefs were low at the beginning of the program. The participants significantly increased their personal efficacy beliefs for teaching mathematics as they completed the two courses of mathematics teaching methodology.

Flores, Patterson, Shippen, Hinton, & Franklin (2010) noted a positive relationship between efficacy beliefs and teachers' ability to solve mathematical word problems among both pre-service and practicing special education teachers. The researchers found that participants who had higher beliefs of efficacy scores in teaching mathematics also showed higher scores in mathematics problem solving.

Statement of the Problem

The national standards are used as a foundational structure and provide a basis for instruction, but do not necessarily eliminate teachers' individual issues and concerns with mathematics (Kahle, 2008). A teacher's anxiety and beliefs toward mathematics can be communicated to students through instruction, or lack thereof, and may have a significant negative impact on students‘ mathematical experiences and attitudes. Mathematically anxious teachers who avoid teaching mathematics put their students at a significant disadvantage in mastering grade level mathematics (Hembree, 1990; Scarpello, 2007; Sherman & Christian, 1999).

While extensive research on mathematics anxiety and self-efficacy has been conducted, the focus has been on how the constructs affect student achievement, gender, or pre-service teachers. There is a gap in the literature focusing on elementary teachers' mathematics anxiety and mathematical self -efficacy as predictors of mathematical teaching efficacy. The mathematics anxiety elementary teachers may exhibit, or their low sense of mathematical self-efficacy, may make them more reluctant to implement the mathematical instruction necessary for student mastery. By recognizing the factors that negatively influence teachers' mathematical instruction, efforts can be made toward alleviating them.

Purpose of Study

The purpose of this study was to explore whether elementary mathematics teachers' mathematics anxiety and/or mathematical efficacy predict their mathematical teaching efficacy. Lyons & Beilock (2012) found that math anxiety is a very real phenomenon with wide ranging consequences. They found that math anxious people had the same response to the anticipation to doing mathematics as they did to the anticipation of a sensation such as pain. Since we tend to avoid pain, it is likely that math anxious people work very hard to avoid mathematics.

Peker & Ertekin, (2011) found that there was a link between math anxiety and anxiety about teaching mathematics. Teachers who were afraid of doing mathematics were more likely to be afraid of teaching mathematics. They also found that it could lead to behaviors in the teacher that can be detrimental to the mathematics achievement in students. According to Sloan (2010), teachers who reported a dislike of mathematics spent 50% less time teaching mathematics, and teachers with negative attitudes toward mathematics frequently relied more on teaching skills and facts while disregarding cognitive thought processes and mathematical reasoning which fostered feelings of anxiety in students.

Research Questions

The research questions that guided this study were:

1. Do mathematics anxiety and mathematics self-efficacy predict mathematical teaching efficacy in elementary mathematics teachers?
2. Are elementary teachers with low anxiety and high mathematics self-efficacy more likely to use best practices in mathematics instruction?
3. How do mathematics anxiety and mathematics self-efficacy impact the strategies teachers use in their mathematics instruction?

Hypotheses

The hypotheses evaluated in this study are:

1. H_1= Mathematics anxiety and mathematics self-efficacy are good predictors of mathematics teaching efficacy.
2. H_2 = Elementary mathematics teachers with low anxiety and high mathematics self-efficacy use best practices in mathematics instruction.
3. H_3 = Elementary teachers with low mathematics anxiety and high mathematics self-efficacy do not use traditional strategies to teach mathematics instruction.

Definition of Terms

Conceptual instruction – A method of classroom teaching where multiple ways are modeled to find an answer, use numerous solution strategies, or instruct how to construct one's own algorithm; a foundational understanding of the reasoning behind why a process works and how it is used in problem-solving situations (Hiebert, 1986; National Council of Teachers of Mathematics, 2000).

Elementary school teacher – A certified, licensed educator who practices education in a school setting; he or she is currently working in a grade level within the kindergarten through sixth (K-6) grade range, and is deemed highly qualified according to the licensure standards of the state and the No Child Left Behind Act of 2001 (PL 107-110). These individuals are only required to be highly qualified at the elementary level and are not required to have a content focus or certification in the area of mathematics (Alabama Department of Education, 2015).

Instructional practices – Approaches that a teacher may take to actively engage students in learning. (Midgley, Kaplan & Middleton, 2000; Turner, Meyer, Cox, Logan, DiCintio, & Thomas, 1998)

Mathematics anxiety – A tense feeling that interferes with the manipulation and understanding of how to work with numbers causing a negative attitude toward mathematics, avoidance of mathematical thinking, limited career choices, lack of self-confidence, and fear of the content (Ashcraft, 2002;Richardson & Suinn, 1972; Tobias, 1978).

Mathematical self-efficacy – An individual's perception of his or her personal mathematical ability in solving mathematical problems and completing mathematical tasks (Hackett & Betz, 1989; Kahle, 2008).

Mathematical teaching self-efficacy –A person's perception of his or her ability to effectively teach others mathematics, and promote student learning, in alignment with personal confidence and content knowledge (Bandura, 1986; Kahle, 2008; Woolfolk-Hoy & Spero, 2005).

Procedural instruction – The systematic, regimented method of content delivery that provides rules and guidelines for the successful completion of a mathematical algorithm by learning the steps to an algorithm, memorizing definitions, and practicing multiplication facts through rote memory (Dweck, 2000).

Productive struggle- Opportunities for delving more deeply into understanding the mathematical structure of problems and relationships among mathematical ideas, instead of simply seeking correct solution (National Council of Teachers of Mathematics, 2014).

Self-efficacy - An individual's perceived ability that he or she is capable of accomplishing a task within a specific context (Bandura, 1977,1986, 1997)

Chapter II.

REVIEW OF LITERATURE

Introduction

We live in a time of extraordinary and accelerating change and because of this, the need for students to become mathematically literate is vital (NCTM), 2000). "The globalization of markets, the spread of information technologies, and the premium being paid for workforce skills all emphasize the mounting need for proficiency in mathematics" (National Research Council (NRC), 2001,xiii). However, learning mathematics requires an environment that is supportive, collaborative, and promotes creative and critical thinking. It requires a teacher who is well qualified to teach mathematics, one who is familiar and knowledgeable with the mathematical content; is skilled at using a variety of effective pedagogical strategies and who possess a disposition toward teaching mathematics that inspires, motivates and encourages students.

The emphasis on teacher accountability and student achievement, as well as the development of the Common Core State Standards for Mathematics, has placed greater importance on the teacher's ability to teach mathematical concepts and skills and provide the level of rigor that students should know (Council of Chief State School Officers, 2013). However, for some elementary teachers, the constructs of mathematics anxiety, mathematics self-efficacy, and mathematics teaching self-efficacy hinder them from providing students with that type of environment and level of rigor. This chapter reviews the literature on the constructs and how they relate to and affect the mathematics instruction of elementary teachers.

Theoretical Framework

Mathematics teaching self-efficacy is based on the work of Bandura (1977) who laid the foundation for the construct of self-efficacy. Prior to 1977, existing learning theories did not address the effect of self-beliefs on the capacity to learn (Pajares, 2002). Bandura's (1977) work on prevalent social learning theories emphasized environmental factors and biological influences in the development of human behavior, and emphasized the role of self- efficacy, or cognition.

Bandura emphasized the role that self-beliefs play in enabling a person to control his or her thoughts, actions, and feelings. He stated, "What people think, believe, and feel affects how they behave" (Bandura, 1986, p.25). Bandura (1986) defined self-efficacy as, "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance" (p.391). Self-efficacy provides the foundation for motivation, well being, and personal accomplishment because unless an individual believes his or her actions can produce a desired outcome, there is no motivation to initiate or complete the task (Pajares, 2002). Bandura's (1997) statement, "People's level of motivation, affective states, and actions are based more on what they believe than on what is objectively true" (p.2), provides a rationale for trying to understand a person's beliefs about his or her capabilities instead of assessing what he or she is actually capable of accomplishing based on previous attainments, skills, or knowledge.

Bandura (1997) stated that self-efficacy can be formed from four sources. The most influential source is a result of an individual's past performance, called mastery experience. Outcomes that are considered to successfully increase self-efficacy. The second source originates from observing others perform a task, also known as vicarious experience. Although weaker than mastery experience in raising self-efficacy, if there is limited prior personal experience, individuals become more sensitive to that experience. Social persuasion, which involves the verbal judgments of others, is the third source. Finally, emotional states such as anxiety or stress can impact self-efficacy. When individual experiences negative thoughts about his or her capabilities, those affective reactions can lower self-efficacy.

Mathematics Anxiety

Definition

Fears from past experiences with mathematics are a leading cause of mathematics anxiety in teachers (Harper & Daane, 1998). As Tobias (1990) pointed out, mathematics anxiety is also felt when using mathematical algorithms, discussing mathematics, or even taking a mathematics test. Mathematics educators have known of mathematics anxiety for years (Gresham, 2007; Sloan et al., 2002). Initial research and awareness of the phenomenon of mathematics anxiety began with teacher observation during the early 1950s by Dreger and Aiken (1957). They 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. Number anxiety was determined to be the presence of a syndrome of emotional reactions to arithmetic and mathematics (Dreger & Aiken, 1957). As a result, Dreger and Aiken agreed on a consistent set of criteria to define mathematics or number anxiety as "an emotional disturbance in the presence of mathematics" (p. 344). This preliminary work on mathematics 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 mathematics anxiety (Dreger & Aiken, 1957).

Researchers since Dreger and Aiken (1957) have generated multiple, but similar, criteria to explain, or define, mathematics anxiety. Mathematics 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). Mathematics 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, 2007); and as not being able to do well with numbers (Tobias, 1990). 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).

According to Hadfield and McNeil (1994) the causes of mathematics anxiety can be divided into three areas: environmental, intellectual, and personality factors. Environmental factors include negative experiences in the classroom, parental pressure, insensitive teachers, mathematics presented as rigid sets of rules, and non participatory classrooms (Dossel, 1993; Tobias: 1990; Trujillo & Hadfield, 1999). Intellectual factors include being taught with mismatched learning styles, student attitude and lack of persistence, self doubt, lack of confidence in mathematical ability, and lack of perceived usefulness of mathematics (Ceman, 1987; Miller & Mitchell, 1994; Trujillo & Hadfield, 1999). Personality factors include reluctance to ask questions due to shyness, low self esteem, and viewing mathematics as a male domain (Ceman, 1987, Levine, 1996, Miller & Mitchell, 1994; Trujillo & Hadfield, 1999). While not all classroom environments are negative, these factors have implications for classroom teachers, both in their own mathematics anxiety, but also in counteracting mathematics anxiety in their students.

Teachers' Mathematics Anxiety and Instructional Practices

Teaching mathematics from the conceptual standpoint remains the main goal of the current mathematics reform movement; it is, nevertheless viewed as threatening for many prospective and practicing elementary teachers (Tobias, 2014; Uusimaki & Nason, 2004). It is not surprising that many classroom teachers feel isolated from the reform process; for teaching mathematics using inquiry based strategies can be intimidating and extremely difficult, even for those who have training and experience (Ernest, 1998). Many teachers are asked to teach mathematics in a way that is completely different from the way in which they were taught mathematics. Furthermore, first year teachers especially have difficulty and experience anxiety in teaching using inquiry based instructional practices (Raymond, 1997). Many prospective teachers enter education programs believing the content in the elementary grades is simple and that they already have the knowledge they need to teach (Raymond, 1997; Uusimaki & Nason, 2004). This belief is not the case with mathematics, however, for the level of content knowledge they have received is often not adequate for teaching mathematics (Hembree, 1990).

Numerous studies have shown that teachers who experience mathematics anxiety tend to use more traditional methods of instruction to teach mathematics (Brush, 1981; Bush, 1989; Karp, 1991). A study conducted by Brush (1981) investigated the mathematics anxiety levels of 31 upper level elementary teachers and their selected teaching practices. Teachers were administered the Mathematics Anxiety Rating Scale, and were required to audio record typical mathematics lessons. The investigator also observed each classroom. The findings indicated that teachers with high levels of mathematics anxiety tend to teach using more traditional methods, while those with lower anxiety levels used more games and activities in their mathematics lessons (Brush, 1981).

Bush (1989) conducted a study regarding mathematics anxiety of upper level elementary teachers. Bush focused on how teachers' mathematics anxiety related to student anxiety and achievement, teaching exercises, and teacher characteristics. The results of the study indicated that mathematics anxious teachers taught using traditional methods. According to Bush (1989), the teachers were insecure and failed to incorporate activities that allowed students to take more mathematical risks.

Karp (1991) studied the mathematical attitudes and instructional behaviors of elementary teachers in grades 4-6. Teachers demonstrated only one correct way to solve problems and students were not allowed much time to interact throughout the lesson. According to Karp (1991), the teachers indicated that the mathematics instructor was the primary mathematical authority, and this left the students dependent on the teacher for acquiring the information about the subject. Overall, teachers with negative attitudes employed methods that typically fostered a dependent atmosphere in the mathematics classroom, whereas teachers with positive attitudes encouraged student initiative and independence (Karp, 1991).

The studies by Bush (1989) and Karp (1991) both illustrate the highly anxious teachers' tendency to use traditional instruction in the mathematics classroom. Students most often received direct instruction and individualized seat work with little to no peer interaction. Additionally, students engaged in limited mathematical discussions became dependent on the classroom teacher as the mathematical authority

(Bush, 1989; Karp, 1991). These teaching practices are in direct conflict with the recommendations of NCTM that advocate a student-centered classroom, which foster social collaboration and peer support through cooperative learning.

Teaching strategies, techniques, and policies throughout an individual's educational career can have a tremendous impact on developing and increasing mathematics anxiety. Furner and Berman (2003) explain that one size fits all instruction, rote instruction, and assigning mathematics homework as punishment all contribute to creating mathematics anxiety. Furthermore, generalizing instruction with no differentiation, assigning mathematical problems that require computation in isolation, and focusing on one correct method for solving a problem also cause feelings of anxiety (Bush, 1989; Jackson & Leffingwell, 1999).

Effects of Mathematics Anxiety on Teachers and Student Achievement

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 mathematics (Gresham, 2007). Research suggests that pre-service teachers experience higher levels of mathematics anxiety than other university students (Bursal & Paznokas, 2006; Haylock, 2001; Swars, Daane, & Giesen, 2006; Trujillo & Hadfield, 1999; Vinson, 2001). According to Trujillo & Hadfield (1999), pre-service teachers are a significant minority when compared to other university students. Hembree (1990) reported that the level of mathematics anxiety of pre-service elementary teachers was the highest of any major on university campuses. Bursal & Paznokas, (2006) suggested that pre-service teachers with high levels of mathematics anxiety have demonstrated low confidence to teach elementary mathematics. Ellsworth

& Bass (2000) and Silva & Roddick (2001) 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 described fear, failure, and subsequent avoidance of mathematics (Ellsworth & Bass, 2000; Silva & Roddick, 2001).

Mathematics anxiety among elementary teachers is a concern with regard to the effectiveness of elementary teachers in teaching mathematics and transference of mathematics 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, 1989; Hembree, 1990). Teachers with high mathematics 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 mathematics 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; Ma, 1999). Teague and Austin-Martin (1981) 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).

Mathematics Teaching Anxiety

Mathematics anxiety has been linked to the teacher and the teaching of mathematics (Furner and Duffy, 2002; Malinsky, Ross, Pannells & McJunkin, 2006; Williams, 1988). As a result, research about mathematics anxiety has been broadened to include research into pre-service and practicing teachers' mathematics teaching anxiety (Peker, 2009). Gardner and Leak (1994) and Levine (1993) described mathematics teaching anxiety as the anxiety that teachers experience during lesson preparation, and during instruction when they teach mathematical concepts, theories and formulas or during problem solving (Peker, 2009). This anxiety can be linked to teachers' content knowledge, pedagogical knowledge, attitudes toward mathematics and self-confidence related to both mathematics anxiety and mathematics teaching anxiety (Peker, 2009).

Mathematically anxious teachers who hold negative attitudes about their teaching of mathematics tend to have a poor understanding of mathematical concepts and poorly developed problem solving competencies (Cohen & Green, 2002); thus, they cannot teach what they do not know. They view mathematics as a set of compartmentalized facts and rules that are to be memorized (Ball, 1996). They do not understand how students learn mathematics, and so are unable to identify and assist students who experience difficulty in mathematics (Harper & Daane, 1998; Kennedy, 1998). In other words, they can't model the behaviors they want to see in their students.

They generally find it difficult to cope with their fear of mathematics. This ought to raise serious concerns about teachers' ability to effectively teach mathematics to young children (Teague & Austin-Martin, 1981;Trice & Ogden, 1986), and the likelihood that they will communicate and transfer their anxiety to their students (Austin, Wadlington, & Bitner, 1992; Gresham, 2007; Kelly & Tomhave, 1985; Swetman, 1994; Uusimaki & Nason, 2004).

Swars et al. (2006), Vinson (2001), and Hembree (1990) posited that mathematically anxious teachers tend to employ traditional teaching strategies such as lecturing, rather than collaborative strategies. They spend more time on whole group instruction rather than differentiated instruction. Mathematically anxious teachers rely heavily on mathematics textbooks to direct the instruction, rote memorization, teach for skills acquisition rather than conceptual understanding of mathematical concepts. They assign the same work to all students, rather than meeting the needs of diverse learners in the classroom by providing scaffolding or tiered instruction. They emphasize solving textbook problems and algorithmic problem solving (Alsup, 2003), rather than spending time on problem solving activities and linking mathematical concepts to the real world. They are less confident about teaching mathematics (Brady & Bowd, 2005; Bursal & Paznokas, 2006), and have low mathematics teaching efficacy (Swars, Daane & Giesen, 2006). Swars (2005) found that elementary teachers with low mathematics anxiety were highly efficacious mathematics teachers.

Mathematics Teaching Anxiety and Gender Differences

Research on mathematics teaching anxiety and gender is conflicting with regard to mathematics anxiety (Hembree, 1990; Ma, 1999). Researchers are still searching to find the differences between males and females when working through mathematics anxiety. Beilock et al. (2010) identified issues that arose when elementary school teachers exhibited mathematics anxiety. They conducted a study that included seventeen first- and second-grade female teachers and fifty-two boys and sixty-five girls from the teachers' classrooms. The teachers were assessed for mathematics anxiety, and the students were assessed for their academic achievement and beliefs about gender and academic success in mathematics. The researchers found that female students' end-of-the-school-year mathematics achievement was negatively affected by their teachers' mathematics anxieties, which influenced the girls' gender ability beliefs, although there was no difference found at the beginning of the school year with the initial testing. Beilock et al. (2010) concluded that the teachers' mathematics anxiety, due to gender and role influence, is the largest contributing factor of the girls' decreased confidence in their own mathematical abilities, and the modeled anxiety leads to a decline in the girls' mathematical achievement. Female teachers' mathematics anxiety was not related to boys' mathematics gender stereotypes or to boys' mathematics achievement. More than 90% of practicing elementary school teachers are female, and elementary female students are found to be more sensitive to gender roles and same-gender teacher influence, in part, because of commonly held beliefs about gender and ability (Serbin & Sprafkin, 1986). Because of this, Beilock et al. (2010) concluded that mathematics anxiety demonstrated by elementary female students is fostered by the teachers' gender ability beliefs and anxieties regarding the subject of mathematics.

Documented Methods of Addressing Mathematics Anxiety

The NCTM (2009) maintains that by gaining competence in mathematical skills, teachers will have less anxiety about, and more success teaching, mathematics. Most of the research on relieving mathematics 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. Malinsky et al. (2006) claimed that mathematics anxiety in pre-service teachers may be reduced by ensuring they develop conceptual understanding of mathematical content before being taught procedural knowledge. The most practical solution to teacher mathematics anxiety is to ensure teachers participate in an elementary mathematics methods courses and/or similar professional development opportunities. Previous research (Brady & Bowd, 2005; Gresham, 2007; 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; Nilseen, Gudmundsdottir, & Wangsmo-Cappelen, 1993). 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, 2007).

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 (NCTM, 2000). 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, 1993; Vinson, 2001). Interviews in a study by Swars (2005) suggest that teachers need experiences with mathematics courses that address past experiences with mathematics and build a self-awareness of negative experiences. Addressing self-awareness may support reduction in mathematics anxiety (Furner & Duffy, 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 suggested that pre-service teachers who successfully complete a mathematics education course in which they directly participate, comprehend, and experience hands-on lessons,discuss mathematical concepts, investigate reasoning, and are involved in problem- solving situations, will demonstrate decreased mathematics anxiety.

Liu (2008) investigated the use of on-line discussions of anxiety toward teaching mathematics in elementary teacher candidates using a small sample of 39 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) noted that until undergraduate programs are changed for pre-service teachers in mathematics, mathematics education in elementary schools will continue to be a concern. He contended professional development that addresses content knowledge is imperative. Wu cited a study by Ball (1990), which claimed that most mathematics professional development in school systems is focused on pedagogy rather than content for elementary teachers. He noted, "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).

Self-Efficacy, Mathematical Self-Efficacy, and Teaching Self-Efficacy

The construct of self-efficacy can be traced to the social cognitive theory of Bandura (1997), who deconstructed self-efficacy into two behavioral constructs: efficacy expectations and outcome expectations. Efficacy expectations refer to "an individual's personal belief that he/she has the capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). On the other hand, outcome expectation is an individual's personal belief that a particular behavior will yield a specific outcome (Swars et al., 2007).

This explanation of self-efficacy does not refer to an individual's actual abilities to perform a task, but his/her perceived ability to perform the task. Thus, 2 individuals with the same skills or abilities may experience different levels of success at the same task, depending on their beliefs about their own efficacy for performing the task. It is the combination of positive self-efficacy and skills and knowledge that are required for performing a given task (Huinker & Madison, 1997). Bandura (1986) and Pajares (1996) attributed efficacy beliefs to an individual's previous experiences, which are specific to situations and contexts.

Self-Efficacy

Self-efficacy is a term used to describe an individual's beliefs, or judgments, of their personal capacity to engage in certain actions. According to Bandura (1986), beliefs influence the amount of effort an individual invests in a task and the motivation to persist in times of difficulty. These self-efficacy beliefs impact a number of behaviors that include academic achievement, career choice, athletic performance, job performance, and recovery from an illness. Bandura (1977) established that self-efficacy indicates an individual's future-oriented beliefs about the level of competence he or she can have in any given situation. Kahle (2008) emphasized that self-efficacy directs a person's choices regarding any personal skill ability, job success and attainment, and individual course selection for higher education because these things are directed by an individual's beliefs in his or her own abilities. Kahle (2008) continued by noting that self-efficacy constitutes a large part of the educational setting in that it influences academic goals, motivation, effort, interest, and self-concept of students and teachers.

Tschannen-Moran et al. (1998) found that individuals who over or underestimate their own capabilities may influence other people's use of the skills they possess. Because self-efficacy is deemed as a strong predictor of behavior (Bandura, 1997), an individual's capability is only as good as its execution, and self-doubt can easily overrule the best skills.

Teacher Self Efficacy

Teacher self-efficacy is identified as a type of self-efficacy that focuses on the views of teachers and their beliefs in their ability to teach and be effective in the classroom. Teacher self-efficacy can also be identified as a teachers belief that he/she can make a difference in how well a student learns or the extent to which they can affect students' achievement (Guskey & Passaro, 1994). Teacher self-efficacy has been related to "teachers" classroom behaviors, their openness to new ideas, and their attitudes toward teaching" (Tschannen-Moran & Hoy, 2001 p. 215). Additionally, Tschannen-Moran, Woolfolk-Hoy, & Hoy, 2001) found that teacher self-efficacy influenced student performance, student attitudes toward learning, and student growth. Tschannen-Moran and Hoy (2001) stated, " Teacher efficacy has proved to be powerfully related to many meaningful educational outcomes such as teachers' persistence, enthusiasm, commitment, and instructional behavior, as well as student outcomes such as achievement, motivation, and self-efficacy beliefs" (p.783). With all of these crucial factors related to teacher self-efficacy, educational researchers have focused on understanding teacher self efficacy, its relationship to student learning, and how it can be improved.

When discussing teacher self-efficacy, educators often are confused by the distinction between beliefs and knowledge (Pajares, 1992). Knowledge of the subject is different than a feeling about teaching it, yet often the knowledge that one has impacts the feeling about teaching it. Pajares (1992) explained and defined the concepts stating, "Knowledge is the cognitive outcome of thought and belief is the affective outcome" (p. 310).

Miller and Dollard (1941) proposed that behavior and environment interact to influence the beliefs of a person. Both personal student effects and school level effects have been identified as environmental factors that can influence a teacher's self – efficacy (Zimmerman, 1981). Personal student effects have been shown to include the type of students that make up a class and their abilities and behavior, while school level effects have been shown to include the climate of a school, the relationship that a teacher has with the principal, and the way in which decisions are made in the school (Zimmerman, 1981). Depending on these external factors, researchers have found that teacher self- efficacy can be similar across an entire school and this collective efficacy can be very powerful in its effect on student achievement (Tschannen-Moran, Hoy & Hoy, 1998).

As Tschannen-Moran and Hoy and Hoy (1998) stated, "Teacher efficacy is the teacher's belief in his/her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233). The level of self-efficacy that a teacher has changes as he/she is faced with new challenges. For example, a new content or grade level may create uneasiness and impact a person's level of teacher self-efficacy. Teacher self-efficacy is very cyclical in nature, which is one of the main reasons it is so important to educational research. Higher self-efficacy leads to greater effort, motivation, ability to instruct, which often leads to better student and teacher performance, which in turn leads to higher self-efficacy for the teacher. The reverse is also true. Lower self-efficacy leads to less persistence and motivation, which often leads to less effort and poor student achievement, which in turn leads to a lower sense of teacher self-efficacy (Tschannen-Moran, Hoy & Hoy, 1998). This cyclical pattern is consistent unless broken with new experiences, confidence, training, or some other critical factor.

Mathematical Teaching Self-Efficacy

Mathematical teaching self-efficacy relates to an individual teacher's personal teaching efficacy in that it reflects a teacher's beliefs that he/she is making a statement regarding the efficacy of his or her own teaching. Mathematical teaching self-efficacy also reflects the confidence that teachers are adequately trained to teach mathematics or that teachers have enough experience to develop strategies for overcoming obstacles to student learning in the content area of mathematics (Ashton & Webb, 1982). Mathematical teaching self-efficacy is more specific and individualized than a belief about what teachers in general can accomplish because it is related not only to personal teaching beliefs, but also to a specified content area (Tschannen-Moran et al., 1998).

According to Kahle (2008), teachers' mathematical teaching self-efficacy was related to teacher knowledge, teacher preparation, student achievement, personal efficacy, and vicarious experiences. This concept of self-efficacy was in alignment with Bandura's (1986) social cognitive learning theory. As noted in previous studies related to general teacher self efficacy, efficacious behaviors in teachers resulted in better discipline, effective classroom management, motivation among students, and increased student achievement (Pintrich & Schunk, 2002; Hoy & Woolfolk, 1990). According to Kahle (2008), these same results occurred when applied to mathematical teaching self-efficacy.

Starko and Schack (1989) identified that teaching self-efficacy is increased through practicing skills or activities in real or simulated experiences. Although teachers are not likely to include thinking strategies that are unfamiliar to them in their lessons, they are capable of becoming more efficacious so they can implement new strategies. By observing other teachers who model the desired instructional behaviors, teachers learn to improve their own instructional and teaching behaviors, which in turn raises teachers' mathematical teaching self-efficacy (Sparks, 1986). Teaching self-efficacy is identified as being influential in teachers' instructional practices, classroom behaviors, and motivation among students (Pintrich & Schunk, 2002; Hoy & Woolfolk, 1990) and because of this, mathematical teaching self-efficacy is found to have a positive, influential effect on the same factors within the mathematics classroom (Midgley, Kaplan, & Middleton, 1989).

Although factors such as mathematics anxiety are shown to have negative effects on teachers' classroom behaviors and instructional practices (Jackson & Leffingwell, 1999), the results of Starko and Schack's (1989) study indicate that steps can be taken to positively influence teachers' self-efficacy to counteract the negative influences.

Standards Based Movement

The view of what constitutes effective mathematics instruction has changed drastically over the years. Controversy about mathematics instruction erupted during the 1940s. With national attention focused on war, the purpose of mathematics education was centered on the preparation for the military and the economy (Schoenfeld, 2004). During World War II, there was heightened public awareness that U.S. students lacked the mathematical skills needed to compete worldwide and that the mathematics curriculum needed to be changed (Herrera & Owens, 2001). A national endorsement for the allotment of resources designated to promote mathematics and science education was heightened and advanced with the launch of Sputnik in 1957. As a response, Congress passed the 1958 National Defense Education Act to increase the number of science, math, and foreign language majors and to contribute to school construction (Klein, 2003). During the late 1950s, individual high school and college teachers started to write their own texts following the suggestions of the major curriculum groups such as the School Mathematics Study Group, the Ball State Project, and the Greater Cleveland Mathematics Program (Klein, 2003). This new math led to many parents and teachers feeling disenfranchised and many elementary teachers felt lost without support or understanding the new curriculum. The decade of the 1970s brought a back to the basics era in which there was widespread sentiment that the new math curricula had failed and there was a need to return to basic mathematics (Herrera & Owens, 2001). There was a push to relinquish mathematics curricula that focused on problem solving and logic and return to a mathematics curriculum that focused on computation, procedures, and fluency. Reaction to this movement grew among the mathematics community who questioned these changes and the low priority given to problem solving. These concerns prompted the National Council of Teachers of Mathematics (NCTM) to form a committee to develop recommendations for school mathematics. The result was the publication of *Agenda for Action* (1980), a position statement that placed problem solving as the curriculum focus, recommended that the definition of "basic skills" be broadened to include reasoning and logic and promoted the use of calculators and computers in the classroom (Herrera & Owens, 2001). Although this publication brought about some direction for change in the area of mathematics instruction, its impact was insufficient to suppress the outcry of concerns from politicians and the public. With concerns growing louder, the publication of *A Nation At Risk* (National Commission for Excellence in Education (NCEE), 1983) compounded these concerns of a lack of problem solving skills and struck a note of urgency with mathematics educators when they stated "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war" (NCEE, 1983, p.5). The response from NCTM was the publication of *Curriculum and Evaluation Standards* (1989). This publication, sometimes referred to as the "NCTM Standards," stressed problem solving, communication, connections, and reasoning in mathematics education (NCTM, 1991). In 1991, NCTM followed up with *Professional Standards for Teaching Mathematics.* This set of standards presented a vision of what teaching should entail to support the changes in curriculum as set out in *Curriculum and Evaluation Standards*. It spelled out "what teachers needed to know to teach toward new goals for mathematics education and how teaching should be evaluated for the purpose of improvement" (NCTM, 1991, p. vii). NCTM followed with the 1995 release of

Assessment Standards for Teaching Mathematics. NCTM produced this important document because "new assessment strategies and practices needed to be developed that would enable teachers and others to assess students' performance in a manner that reflected the NCTM's reform vision for school mathematics" (NCTM, 1995, p. 1). In 2000, NCTM released *Principles and Standards for School Mathematics*. This document updated the 1989 publication *Curriculum and Evaluation Standards,* and included some components of both *Professional Standards for Teaching Mathematics* and *Assessment Standards for Teaching Mathematics* (NCTM, 2000). *Principles and Standards of School Mathematics* (NCTM, 2000) served as a major influence for the changes and trends of mathematics education and reform. Pri*nciples and Standards of School Mathematics* (NCTM, 2000) identified six principles of high-quality mathematics instruction. They are the Equity Principle, Curriculum Principle, Teaching Principle, Learning Principle, Assessment Principle, and Technology Principle. *Principles and Standards of School Mathematics* also included five content standards (Number and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability) as well as five process standards (problem solving, reasoning and proof, communication, connections, and representations) (NCTM, 2000). Problem solving is the core of any mathematics curriculum according to NCTM (2000). Reasoning is also important. Students who are exposed to the logic behind mathematical procedures are more likely to be able to learn and correctly apply those procedures than students who attempt to apply rules without regard to their reasonableness (Carpenter, Franke, Jacobs, Fenemma, & Empson, 1998; Hiebert & Wearne, 1996; NCTM, 2000). Communication especially is important for assessment. Students must learn to explain, write, draw, or otherwise show and justify what they have learned. Connections refer to relationships among mathematics topics as well as connections to other subject areas and to real-life situations. By stressing connections, one can show the significance and importance of mathematics. Students must also be able to make connections among mathematical representations (Coxford, 1995). There are often a variety of representations for a single mathematical concept. By learning several strategies or paths to a solution for a single concept, teachers can adjust their teaching methods to the needs and abilities of their students. Students should learn a variety of representations to best express and use their mathematical knowledge (Burris, 2014).

In 2001, the National Research Council (NRC) released a report on pre K-8 math education entitled *Adding It Up: Helping Children Learn Mathematics*. This publication explored how students in pre-K through eighth grade learn mathematics and recommended how teaching, curricula, and teacher education should change to improve mathematics learning during these critical years (National Research Council, 2001). The Committee on Mathematics Learning, which was created by the National Research Council in 1998, developed strands of mathematical proficiency that are essential to learning mathematics. In developing the strands, the committee's goal was to, "provide a framework for discussing the knowledge, skills, abilities, and beliefs that constitute mathematical proficiency" (NRC, 2001, p.116). The five strands are: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. The authors emphasized that the five strands are interwoven and interdependent in the development of proficiency in mathematics (NRC, 2001).

In 2006, NCTM published *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence*. This publication offered both immediate and long-term suggestions for improving the teaching and learning of mathematics. It provided ideas that might encourage rich discussions among teachers about areas to emphasize as they considered the needs of their students (NCTM, 2006). In this publication, three curriculum focal points were identified and described for each grade level, pre K–8, along with connections to guide the integration of the focal points at that grade level and across grade levels, to form a comprehensive mathematics curriculum, as well as to enable students to learn the content in the context of a focused and cohesive curriculum that implemented problem solving, reasoning, and critical thinking (NCTM, 2006).

NCTM recognized the need to focus discussions on high school curricula reform. It suggested practical changes that would refocus learning on reasoning and sense making and, in 2009, published *Focus in High School Mathematics: Reasoning and Sense Making* (NCTM). This publication suggested that the more mathematics instruction builds on what students have previously learned, the more students would be able to learn and retain as they progressed from prekindergarten through college. A focus on mathematical reasoning and sense making helps students to use mathematics more effectively in making wise decisions in the workplace and as citizens (NCTM, 2009).

The Common Core State Standards-Mathematics (CCSS-M) was released in 2010. The CCSS-M is a set of mathematics standards for grades K-12. The Council of Chief State School Officers (CCSSO) and the National Governors Association (NGA) commissioned the CCSS-M. The mission of the Common Core State Standards Initiative was to provide a consistent, clear understanding of what students were expected to learn (Council of Chief State School Officers, 2013). The standards are designed to be rigorous and significant to the real world, reflecting the knowledge and skills that students need to be successful in college and careers. The Common Core State Standards are not national or federal standards, but rather a set of standards that may be voluntarily adopted by each state. Presently, forty-two states, two territories and the District of Columbia have adopted the standards (CCSSO, 2015). The Common Core State Standards for Mathematics (CCSSM) are organized in two groups: (1) Standards for Mathematical Practice and (2) Standards for Mathematical Content. The Standards for Mathematical Practice describe ways of thinking about mathematics that need to be developed in order for students to become mathematically proficient. The practice standards were developed based on the National Council of Teachers of Mathematics (NCTM) process standards and the strands of mathematical proficiency published in *Adding It Up* (NRC, 2001). The Standards for Mathematical Practice permeate the Standards for Mathematical Content for all grades. The Standards for Mathematical Content are designed to be a balance of standards involving procedures and understanding.

The state of Alabama developed and adopted the Alabama College and Career Readiness Standards (ACCRS) in 2010 (Alabama State Department of Education, 2015). By combining both the Common Core State Standards and Alabama's education standards, the state of Alabama adopted one of the most comprehensive sets of standards in the nation ensuring students are prepared for a successful future in the ever-expanding global environment (Alabama State Department of Education, 2015). The standards provide a clear and consistent understanding of what students are expected to learn (Alabama State Department of Education, 2015). Consistent standards provide appropriate benchmarks for all students and allow teachers to effectively help students become successful lifelong learners. The mathematics standards stress not only procedural skills, but also conceptual understanding to make sure students are learning the critical information they need to succeed at higher levels (Alabama State Department of Education, 2015).

Realizing that standards alone will not ensure mathematical success for all students, NCTM published *Principles to Actions: Ensuring Mathematical Success for All* in 2014. This publication set forth a set of research-based actions for all teachers and stakeholders involved in mathematics education. These actions are based on NCTM's original set of principles outlined in *Principles and Standards for School Mathematics* (2000). *Principles to Actions: Ensuring Mathematical Success for All* (NCTM, 2014) suggested specific actions that teachers need to utilize to realize the goal of mathematical success for all students.

Instructional Practices and Standards Based Movement

The implementation of standards either through CCSS-M or state standards based on the CCSS-M, provides guidance and direction, and helps focus and clarifies common outcomes. It motivates the development of new instructional resources and assessments. But, it does not tell teachers and other mathematics educators how to begin to make essential changes to implement the standards. Moreover, it does not describe or prescribe the essential conditions required to ensure mathematical success for all students (NCTM, 2014).

Cultural beliefs about the teaching and learning of mathematics continue to be obstacles to consistent implementation of effective mathematics instruction (Handal, 2003, NCTM, 2014; Philipp, 2007). Two schools of thought reflect current mathematical teaching practice. One is a belief in a more traditional approach to learning mathematics. This approach focuses on memorization of facts, formulas, and procedures and then practice these skills over and over again (NCTM, 2014; Sam & Ernest, 2000). The second belief is that mathematics instruction should be focused on engaging students in real world mathematical tasks that promote reasoning and problem solving (NCTM, 2014, NCTM, 2009, NRC, 2001). Lack of agreement about what constitutes effective mathematics instruction restricts schools and school systems from establishing coherent expectations for high quality productive mathematics instruction (Ball & Forzani, 2011, NCTM, 2014).

NCTM's (2014) latest publication, *Principles to Action: Ensuring Mathematical Success For All,* provides eight mathematical teaching practices that offer a common lens for moving toward improved instructional practice and for teachers to support one another to become skilled in ways that ensure successful mathematical learning for all students. The eight mathematical practices represent a core set of rigorous practices and essential teaching skills necessary to promote deep learning of mathematics. Practice 1 is to establish mathematical goals to focus learning. Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals with the learning progressions, and uses the goals to guide instructional decisions; Practice 2 is to implement tasks that promote reasoning and problem solving. Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies. Practice 3 is to use and connect mathematical representations. Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving. Practice 4 is to facilitate meaningful mathematical discourse. Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments. Practice 5 is to pose purposeful questions. Effective teaching of mathematics use purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships. Practice 6 is to build procedural fluency from conceptual understanding. Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems. Practice 7 is to support productive struggle in learning mathematics. Effective teaching of mathematics consistently provides students with opportunities and support to engage in productive struggle as they grapple with mathematical ideas and relationships. Practice 8 is to elicit and use evidence of student thinking. Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning (NCTM, 2014).

Although the teaching of mathematics is not limited to the eight Mathematical Teaching Practices listed above, the practices are suggested as a framework for strengthening the teaching and learning of mathematics. Teachers need to collaboratively support one another in moving toward improved instruction. Effective mathematics teaching begins with teachers clarifying and understanding the mathematics that students need to learn and how it develops along the learning progressions (NCTM, 2014).

Summary

Through reviewing the research regarding mathematics, it is evident that the differing theories, behaviors, beliefs, attitudes, efficacies, and instructional beliefs of elementary educators has impacted student learning throughout the years (Gibson & Dembo, 1984; Muijs & Reynolds, 2002; Tom, Cooper, & McGraw, 1984). The relationships between and among mathematics anxiety, mathematics self-efficacy, mathematics teaching self-efficacy, and instructional practices appear to be relevant as educators pursue better and more efficient mathematical teaching practices. With the focus on standards based mathematics instruction, teachers should align their mathematics instruction with the NCTM Standards document that provide opportunities for students to learn mathematics from an inquiry based perspective. However, the endless cycle of these constructs and the relationship among them impact students' and teachers' sense of anxiety, self-efficacy, and learning and further research is needed in this area. The intent of this review of literature was to establish a foundation for research in identifying the relationships between and among mathematics anxiety and mathematics self-efficacy as predictors of mathematical teaching efficacy of elementary school teachers who teach mathematics.

Chapter III.

METHODOLOGY

Although there has been extensive research on mathematics anxiety and self-efficacy, a limited amount is known about the interrelatedness of these constructs and the impact they have on elementary mathematics teachers and their mathematical instructional practices. There also is a gap in the literature related to whether mathematics anxiety and mathematics self-efficacy are good predictors of elementary teachers' mathematical teaching self-efficacy. The review of literature found that the research conducted on mathematical self-efficacy and mathematical teaching self-efficacy has been limited mainly to post secondary students, including pre-service teachers (Hackett & Betz, 1989, Pajares & Miller, 1995).

Establishing a strong foundation in the content area of mathematics at the elementary level is critically important in order for American students to be competitive among other global competitors (Wallace, 2005). Meeting this challenge is made more difficult when considering the large number of pre-service elementary teachers identified as having mathematics anxiety (Hoy & Woolfolk, 1990; Swars, et al, 2006) and negative feelings about the subject of mathematics (Austin et al. 1992). The literature further suggested teachers' instructional strategies and classroom behaviors are influential in contributing to their students' mathematics anxiety (Furner & Duffy, 2002; Jackson & Leffingwell, 1999) and ultimately poor performance (Swars et al., 2006). The classroomteacher is the most influential factor impacting student achievement (Rockoff, 2004). When a classroom teacher's personal beliefs are influenced, their personal teaching practices change, which in turn influences students and student achievement (Darling-Hammond, 2004; Hidi, 2001; Hoy & Woolfolk, 1990; Thompson, 1992).

This chapter discusses the methodology used to conduct the study. The methodology provided the structure for the assessment used to determine if mathematics anxiety and mathematics self-efficacy predict mathematics teaching self-efficacy. The chapter is divided into the following sections: research questions, null hypotheses, research design, population, instrumentation, data collection, and data analysis.

Research Questions

The research questions that guided this study were:

1. Do mathematics anxiety and mathematics self-efficacy predict mathematical teaching self-efficacy in elementary mathematics teachers?
2. Are elementary teachers with low anxiety and high mathematics self-efficacy more likely to use best practices in mathematics instruction?
3. How do mathematics anxiety and mathematics self-efficacy impact the strategies teachers use in their mathematics instruction?

Research Hypotheses

The hypotheses evaluated in this study are:

1. H_1= Mathematics anxiety and mathematics self-efficacy are good predictors of mathematics teaching efficacy.

2. H_2= Elementary mathematics teachers with low anxiety and high mathematics self-efficacy use best practices in their mathematics instruction.
3. H_3 = Elementary teachers with low mathematics anxiety and high mathematics self-efficacy do not use traditional strategies to teach mathematics instruction.

Research Design

In order to gain a deeper understanding of the issues expressed in the present study, a multiple methods approach was utilized. The inclusion of both qualitative and quantitative data help to strengthen the research design and furnish reliability and credibility to the present study's results (Patton, 1990). The quantitative data consist of the summed total of the Mathematics Anxiety Rating Scale Instrument, the summed total of the Mathematics Self Efficacy Scale, and the summed total of the Mathematics Teaching Efficacy Beliefs Instrument. The researcher utilized a hierarchical multiple regression to determine whether mathematics anxiety and/or mathematics self-efficacy contributed to the prediction of mathematics teaching efficacy. Mathematics self-efficacy was entered in step 1 and mathematics anxiety was entered in step 2 of the analysis. The qualitative data (classroom observation and semi structured interviews) were analyzed using grounded theory. Berg and Lune (2012) stated that by allowing the data to speak for itself and thus allow for the likelihood of theory to be produced, more attention can be given to contradictory cases, and the researcher will not become too attached to another perspective or assumption. In addition, new questions are more likely to be raised. Following the procedures presented by Strauss and Corbin (1998), the data collection process began with the collected data first being analyzed individually using a coding process called open coding. As Berg and Lune (2012) explained, "analysis starts as the data begin to indicate the necessary categories and codes to use and as these elements begin to form patterns…" (p. 367). Coding for categories, or axial coding will then emerge (Bernard & Ryan, 2010). For saturation to occur, the constant comparative method is necessary. The constant comparative method requires the researcher to take one piece of data and compare it to all other pieces of data that are either similar or different. During this process, the researcher begins to look at what makes the piece of data different and/or similar to other pieces of data (Glaser, 1965). This process leads to the development of the theory.

Participants

This study took place during the fall of 2015 in a school system in rural southeast Alabama. The school system is comprised of 15 schools and services more than 11,000 students. The researcher chose to recruit elementary teachers from the entire school district to represent diverse backgrounds and teaching practices. The participants were elementary mathematics teachers in grades one through six. The participants brought a variety of experiences in teaching mathematics in terms of years of teaching, degree/degrees held, and professional development.

The four participants that were selected to participate in the classroom observations and semi structured interviews taught at different elementary schools within the district and had a vast range of teaching experience. Teacher A earned a Bachelor of Science in elementary education and had 12 years teaching experience in second grade. Teacher A participated in both system-wide and sponsored mathematics professional development within the last three years. She has always taught in a self-contained class setting. Teacher B also earned a Bachelor of Science in elementary education. At the time of the study, she was enrolled in an online masters program and was expected to graduate at the end of the semester. She had taught for six years, first grade for four years, and fifth grade for two years. All of her teaching experience had been in a self-contained setting. Teacher B participated in system-wide and sponsored professional development during the last three years. Teacher B also participated in a systemic change project related to mathematics instruction. Teacher C earned a Bachelor of Science degree in early childhood education and had 34 years of teaching experience. She had taught kindergarten for 22 years and first grade for 12 years. Teacher C had participated in system-wide and sponsored mathematics professional development during the last 3 years. She has always taught in a self-contained class setting. Teacher D earned a Masters degree in elementary education and had 26 years teaching experience. Teacher D had taught third grade for four years, fourth grade for 17 years, and sixth grade for five years. Teacher D participated in both system-wide and sponsored mathematics professional development during the last three years. Teacher D has also taught in South Carolina and Mississippi.

Federal regulations require Auburn University's research compliance board to review and approve all research that involves human subjects. The researcher submitted a complete Institutional Review Board (IRB) application to Auburn University's Office of University Research and IRB. The IRB determined the study would not create any harm for the human subject participating in the study and approved the study (See Appendix A).

Instrumentation

The first instrument used to collect data was the *Revised Mathematics Anxiety*

Rating Scale (MARS-R), (Suinn & Winston, 2003). The MARS-R is a 30-item instrument designed to measure the degree of mathematics anxiety. The instrument uses a five category Likert scale with one being low anxiety and five being high anxiety. The MARS-R has acceptable reliability (.97) and validity (.92), comparable to the original MARS. Richardson and Suinn (1972) reported a test retest reliability coefficient of .97 on the original MARS.

The second instrument used to collect data was the *Mathematics Self- Efficacy Scale* by Betz and Hackett (1989). The 34-item instrument measured "beliefs regarding ability to perform various math-related tasks and behaviors" (Betz & Hackett, 1989, p. 122). Respondents indicate their responses on a 10 point Likert scale, with 0 meaning “no confidence at all” and 9 meaning “complete confidence.” Previous research conducted by Betz and Hackett (1983) found that MSES had reliability coefficient alpha of .96 for the total scale and validity coefficient alpha of .95.

The third instrument used to collect data was the *Mathematics Teaching Efficacy Beliefs Instrument* (MTEBI) (Ennochs, Smith, & Huinker, 2000). The MTEBI consists of 21 items, 13 on the Personal Mathematics Teaching Efficacy subscale and eight on the Mathematics Teaching Outcome Expectancy subscale (Ennochs, Smith, & Huinker, 2000). The Personal Mathematics Teaching Efficacy subscale addresses teachers’ beliefs in their individual capabilities to be effective mathematics teachers. The Mathematics Teaching Outcome Expectancy subscale addresses the teachers’ beliefs that effective teaching of mathematics can bring about student learning regardless of external factors. Reliability analysis produced an alpha coefficient of .88 for the Personal Mathematics Teaching Efficacy subscale and an alpha coefficient of .75 for the Mathematics Teaching

Outcome Expectancy subscale (n=324) (Ennochs, Smith & Huinker, 2000). There was no validity coefficient reported, however, confirmatory factor analysis indicated that the two subscales are independent, adding to the construct validity (Ennochs, Smith, & Huinker, 2000).

The fourth instrument used to collect data was the *Mathematics Classroom Observation Protocol for Practices (*Gleason, Livers, & Zelkowsi, 2014). *The Mathematics Classroom Observation Protocol for Practices (MCOP^2)* is a K-16 mathematics classroom instrument designed to measure the degree of alignment of the mathematics classroom with the mathematics standards set out by various national organizations which include the Common Core State Standards in Mathematics: Standards for Mathematical Practice (National Governors Association Center for Best Practices (NGACBP), Council of Chief State School Officers (CCSSO), 2015), and the Process Standards (NCTM, 2000). The MCOP^2 measures two distinct factors: teacher facilitation and student engagement. Gleason, Livers, & Zelkowski (2014) reported a reliability coefficient of .91.

Data Collection

Data were collected in three phases. The first phase aligned with research question 1 (Do mathematics anxiety and mathematics self efficacy predict mathematical teaching efficacy in elementary mathematics teachers?) and consisted of the researcher recruiting and consenting all participants. During the first week of the study, the researcher visited each elementary school to have the participants complete the *Revised Mathematics Anxiety Rating Scale Survey* (R-MARS), the *Mathematics Self-Efficacy Scale* (MSES), and the *Mathematics Teaching Efficacy Beliefs Survey* (MTEBI). The participants completed each of the surveys on their own through self- reporting. The researcher collected the participant surveys and calculated a sum total for each survey.

The second phase of data collection aligned with research question 2 (Are elementary teachers with low anxiety and high mathematics self efficacy more likely to use best practices in mathematics instruction?) and utilized a purposeful sampling method based on the data results of the surveys. From the consented participants, the researcher selected two teachers that scored low on the MARS-R and two teachers that scored high on the *Mathematics Self-Efficacy* (MSES) survey. The participants were selected because their scores represented the lowest scores out of all of the participants on the MARS-R survey or the highest scores out of all of the participants on the MSES survey. The researcher visited the teachers' classrooms twice to observe them teach a mathematics lesson. The researcher utilized the Mathematics Classroom Observation Protocol for Practices ($MCOP^2$) for the observation and to generate data. Each of the observations lasted approximately one hour.

The third phase of data collection aligned with research question 3 (How do mathematics anxiety and mathematics self efficacy impact the strategies teachers use in their mathematics instruction?) and consisted of semi-structured interviews. The researcher consulted with practicing teacher educators to develop the structured interview protocol (Appendix F). The same four participants from the second phase of data collection were interviewed. Semi structured interviews were scheduled with participants and took place in the teacher's classrooms after school had been dismissed. All interviews were audio taped to enable the researcher to create accurate transcriptions of the session for data collection. All transcriptions were double checked for accuracy.

Data Analysis

By utilizing a multiple methods design, different information or data sets were obtained which provided a clearer understanding and helped validate the research. Quantitative data gathered from the surveys were analyzed utilizing hierarchical multiple regression using the Statistical Package for Social Sciences (SPSS). Hierarchical regression is the practice of building successive linear regression models, each adding more predictors. The predictors are added to the regression models in stages in order to determine if they predict the dependent variable (mathematics teaching efficacy) above and beyond the effect of the controlled variables (Creswell, 2003). Corbin and Strauss (2008) stated "qualitative research allows researchers to get at the inner experience of participants, to determine how meanings are formed through and in culture, and to discover rather than test variables" (p.12). Qualitative research is perhaps ideally suited to the construct of teacher beliefs (Pajares, 1992). Understanding of teachers' beliefs can be established by talking directly with teachers, going to their schools, and allowing them to tell their stories (Creswell, 2003). The qualitative data were analyzed using grounded theory. Following the procedures presented by Strauss and Corbin (1998), the data collection process begins with the collected data first being analyzed individually using a coding process called open coding. As Berg and Lune (2012) explained, "analysis starts as the data begin to indicate the necessary categories and codes to use and as these elements begin to form patterns…" (p. 367). Coding for categories, or axial coding will then emerge (Bernard & Ryan, 2010). The qualitative data were utilized to triangulate the data. Triangulation helps facilitate validation of the data through cross verification (Kennedy, 2009). Triangulation is also an attempt to map out, or explain more fully, the richness and complexity of human behavior by studying it from more than one standpoint (Kennedy, 2009).

Generalizability and Transferability

Similar to the concept of external validity in quantitative studies, generalizability and transferability seek to determine if the results relate to other contexts and can be generalized and transferred to those contexts (Lincoln & Guba, 1985; Miles & Huberman, 1994). In this study, I sought to generalize the quantitative findings from the sample to the population and to enhance transferability of the qualitative data by providing adequate detail to draw a well-defined context. I allow the readers the opportunity to decide for themselves whether or not the results are transferable to other circumstances.

Summary

This chapter addressed the research methodology that was employed in this study. A detailed description of the research design, population, instrumentation, data collection, and data analysis of the study was provided. The following chapter presents the findings from the data analysis.

Chapter IV.

RESULTS

The first chapters of this study provided an introduction to the research problem, an overview of the purpose and significance of this study, a review of literature and research describing the constructs of mathematics anxiety and mathematics self- efficacy and their relationship to the construct of mathematics teaching efficacy, and the methods and procedures used to collect and analyze the data. This chapter reports the results of the quantitative and qualitative data collected to respond to each research question and hypothesis.

Research Question One

Do mathematics anxiety and mathematics self efficacy predict mathematical teaching efficacy in elementary mathematics teachers?

H_1= *Mathematics anxiety and mathematics self efficacy are good predictors of mathematics teaching efficacy.*

A hierarchical multiple regression was conducted to determine whether mathematics self-efficacy and/or mathematics anxiety contributed to the prediction of mathematics teaching self efficacy. Based on theoretical grounds, mathematics self-efficacy was entered in step 1, and mathematics anxiety was entered in step 2. According to the R^2 change, mathematics self efficacy explained 3.5% of the variance in mathematics teaching efficacy $F(1, 49)= 1.579$, $p <.05$. Furthermore, mathematics anxiety explained an additional 1.7% of the variance in mathematics teaching self efficacy, $F(1.48) = .869$, $p < .05$. Regression coefficients are reported in Table 1. While mathematics self-efficacy and mathematics anxiety are good predictors of mathematics teaching self-efficacy according to the R^2 change, the standardized coefficients were not significant. Standardized coefficients were $\beta = -0.249$ for mathematics self-efficacy and $\beta = 0.144$ for mathematics anxiety when both variables were included in the model. This means that for 1 standard deviation increase in mathematics teaching efficacy, mathematics self-efficacy decreased .249 points and mathematics anxiety increased .144 points. Results suggest that the hypothesis is not supported.

Table 1

Summary of Hierarchical Regression Analysis for Variables Predicting Mathematics Teaching Self Efficacy

				Unstandardized Coefficients		Standardized Coefficients	
Predictor	R	R^2	R^2 Change	B	Std. Error	Beta	Sig.
Step 1							
Mathematics Self efficacy	.188	.035	.035*	-.086	.064	-.188	.186
Step 2							
Mathematics Self efficacy	.229	.052	.017*	-.114	.071	-.249	.115
Mathematics Anxiety				.040	.043	.144	.356

N=51, *p<.05

Research Question Two

Are elementary teachers with low anxiety and high mathematics self efficacy more likely to use best practices in mathematics instruction?

H_2= Elementary mathematics teachers with low anxiety and high mathematics self efficacy use best practices in mathematics instruction.

Four participants, who were purposefully selected based upon their survey results, were observed teaching a mathematics lesson on two separate occasions. The *Mathematics Classroom Observation Protocol for Practices (MCOP^2)* observation instrument served as the means of gathering data. As discussed in chapter three, the MCOP^2 has two subscales: teacher facilitation and student engagement. The teacher facilitation subscale focused on the role of the teacher as the one who provided structure for the lesson and guided the problem solving process and classroom discourse by allowing students to critically assess their mathematical strategies, build conceptual understanding, model with mathematics, provide tasks that allow for multiple paths to the solution, encourage student thinking, encourage a climate of respect for what others have to say, and maintain precision of mathematical language. The student engagement subscale focused on students exploring, investigating, and problem solving, using a variety of means such as drawings, models, graphs, concrete materials, and manipulatives to represent concepts, engaging in mathematical activities, critically assessing mathematical strategies, persevering in problem solving, allowing student discussions about mathematics and mathematical strategies, students respecting peers and communicating mathematical ideas to peers, and allowing appropriate wait time for students to problem solve.

The data from the classroom observations suggest that while all four participants provided structure to their lessons, all of the lessons were teacher directed and there were no opportunities given for students to problem solve on their own or to build conceptual understanding. All of the lessons focused on procedural strategies instead of giving the students a mathematical task that allowed them to critically assess the thinking and the strategies they used. For example, Teacher A was working on two-digit subtraction without regrouping with her students. She used the SmartBoard to display two-digit subtraction problems to the students. She asked the students to tell her the steps that she needed to do in order to solve the problem. She would work the problem on the SmartBoard as the students told her each step. She stated that "*the most important thing is to start in the ones place.*" The observations also revealed that Teacher A jumped in and told the students what to do to solve the problem if they didn't know the step quickly enough. For example, she told a student to *" put nine in your head and count down three."* In another example, observations revealed that Teacher B was working with students on counting to ten. She began the lesson by having students sing a song that had the students counting to ten. Then, she placed a ten-frame mat on the Elmo projector and reviewed with the students where to start and how to fill in the ten-frame. The teacher rolled a die and called on a student to come to the board to fill in the ten-frame. After calling on several students, she distributed a ten-frame worksheet for the students to complete at their desk. The teacher monitored the students as they worked by walking around and assisting individual students. Additionally, the observations showed that Teacher C was working on the skill of missing addends to ten with a student and told him to *"put three in your head and count up.*" She was working with a few students that were struggling and she told one student to *"count up in your head."* She continued to tell the student to "*put five in your head and count up on your fingers."* At the end of the lesson, teacher C commented to the students *"the easiest way to solve a problem like this is to count up in your head and use your fingers."* Lastly, the observations showed that Teacher D started out the mathematics lesson by reviewing three-digit by one-digit multiplication problems and the strategies that could be used to solve the problems. She reviewed how to multiply using the partial product, expanded form, standard algorithm, and repeated addition strategies. Then, she asked the students "*if they could use any strategy that worked for them?"* The students responded with *"yes."* Next, the teacher stated that they were correct, but *"her personal favorite strategy was the standard algorithm because it was faster and easier."* Teacher D placed three multiplication problems on the board and told the students to solve the problems. As the students were working on the problems, she asked the students which strategy they were using and they all responded *"the standard way."* After the students had completed the problems, the teacher reviewed the solutions by working the problems on the Elmo projector. As teacher D was working out the problems on the projector, she stated, *"she was seeing too many students making weird faces*." She went on to state "*if they were getting incorrect answers, they needed to check their neatness."* She continued to have a discussion with the students about "*why it was important to line your numbers up."* She ended the lesson and discussion by stating that *"the key to math is neatness, so make sure you line your numbers up."*

The classroom observations suggest that students were not given the opportunity to explore, investigate, and problem solve through meaningful mathematical tasks. There were a couple of instances where the participants allowed students to draw the expanded form of a number or problem in order to solve it. For example, teacher A modeled the expanded form of a problem by drawing the rods and cubes. She went on to tell the students that they *"could use either the standard algorithm or drawings/expanded form method for solving the problems."* In another example, teacher C allowed students to use bear counters to help them solve their missing addend problems. Overall, the students were taught through drill and practice and worksheets. There was no opportunity given for students to engage in meaningful mathematics that would allow students to critically assess mathematical strategies and communicate mathematical ideas with their peers.

Findings

Based upon the classroom observations, elementary teachers with low anxiety and high mathematics self-efficacy do not consistently use best practices in mathematics instruction and the hypothesis is not supported. The classroom observation data revealed that both high and low confidence teachers used a more traditional approach to mathematics instruction.

Research Question Three

How do mathematics anxiety and mathematics self-efficacy impact the strategies teachers use in their mathematics instruction?

H_3 = *Elementary teachers with low mathematics anxiety and high mathematics self-efficacy do not use traditional strategies to teach mathematics instruction.*

Introduction

The data collected from the classroom observations were utilized as well as semi - structured interviews to investigate research question three. The semi-structured interviews were conducted with the same four participants as in phase two of the study. The data were coded (Appendix F) and analyzed for major themes and subthemes. The themes are based on the classroom observations, semi-structured interviews, and the triangulation of data. The major themes that emerged were (1) attitudes and beliefs about mathematics, (2) teaching the way I was taught, (3) how to develop mathematics lessons, (4) strategies used to teach mathematics, and (5) administrative decisions. The data continued to reveal subthemes that provide explanation and support for the major themes. A discussion of the subthemes for each major theme follows.

Attitudes and Beliefs about Mathematics

Mathematically Self-Confident.

Two participants who scored high on the Mathematics Self Efficacy Scale (MSES) survey discussed that mathematics was easy for them and they enjoyed teaching mathematics. Teacher A discussed that mathematics had always been easy for her even as a child. She stated *"math is easy for me and it is easy for me to relate it to students and make it easy for them."* She continued to discuss that she is *"always on the lookout for new ways or strategies to teach a math skill so that it will make it easy for the students."* The classroom observations suggest that teacher A was confident, enthusiastic, and positive when teaching mathematics to her students. However, teacher A taught mathematics from a procedural point of view. The observations showed that she worked problems on the SmartBoard as students verbally told her each step to take in order to solve the problem. Also, teacher A jumped in and told students how to solve the problem if they were struggling.

Teacher D discussed that she has always had a love for math and it was a subject that she found easy to teach. She stated that she *"loves math and is very comfortable teaching it*." She continued to discuss that she seems to be the teacher that parents want their children to have because of her ability to make math easy for the students to understand. Again, the classroom observations suggested that teacher D is confident, enthusiastic, and positive about mathematics with her students, but the students are taught mathematics from a traditional approach using procedures and standard algorithms. For example, teacher D reviewed with the students how to solve 3-digit by 1-digit multiplication problems using the standard algorithm. Then, she wrote three multiplication problems on the board and asked the students to solve them. She kept reminding students that the "standard way" was the easiest and fastest way to solve problems.

Comparing quantitative and qualitative results suggests that the teachers have confidence with mathematics because of the approach they use to teaching mathematics. This confidence or attitude may transfer to their students as they become successful at solving mathematical problems using traditional methods. However, this approach does not allow students to make the necessary connections to build conceptual understanding nor does it provide opportunities for students to problem solve and discover solutions for themselves.

Low Confidence.

Two teachers who scored low on the *Mathematics Self Efficacy Scale* (MSES) discussed that they had always struggled with mathematics. Teacher B discussed that even though she had great math teachers in school, math was a nightmare for her. She explained that as a child she was never able to grasp the math skills and concepts quickly and that she became discouraged easily when it came to math. She stated *"she had great teachers who assisted her when she struggled, but she never overcame that struggle."* Teacher B stated that she doesn't like the way that we teach math now. She continued on to say "*she has taught from a textbook for so long, it is really hard for her to wrap her head around this new way of teaching."* She further stated that *"she needs a teacher's guide because if she didn't have one she would teach the skills the way that she was taught and that is not a good thing*." Teacher B explained that she takes her teacher's guide home to practice how to teach the math skill before actually teaching it to the students. She stated, *"I know that I am unsure of what I am teaching in math and sometimes the students have to help me get through a lesson."* Teacher B knows that her attitude and insecurity about math shows through to her students, but she stated, *"She is trying to change it and embrace the new ways to teach math."* The classroom observations suggest that teacher B teaches the basics to students using traditional methods. She tends to incorporate other strategies such as using children's literature or music to teach the math skill for her. For example, teacher B employed a Youtube video that utilized music to teach students the math skill of counting to ten. She also incorporated a lot of worksheets that focus on basic facts and skills rather than providing the students with meaningful mathematical tasks.

Teacher C stated that she struggled with math during school, especially in high school and college, and that she ended up having to work with a tutor one on one. She stated, *"that she is good at basic math, but that big math kind of scares me."* She continued on by saying *"you look at the standards and think how am I supposed to get* *kids to understand this when I don't understand some of it myself."* Furthermore, she said she thinks she is *"too old to learn the new ways to teach math."* The classroom observations revealed that teacher C designed her mathematics lessons around stations. There were two stations where students worked on basic facts such as addition or subtraction and the third station required students to work with her on a particular math skill. She gave the students a problem and then told them to solve it on their dry erase board. She allowed the students to work for a couple of minutes and then she began to assist those students that were struggling by telling them what steps to take in order to solve the problem. She never increased the level of difficulty of the problems at any point during the students' time with her at the station. This is important to note because, with standards based instruction, the level of rigor must increase in order for students to become successful in mathematics.

Comparing qualitative and quantitative results suggested that mathematics teachers with low confidence do not exude a positive attitude about mathematics to their students. Based on classroom observations, they tend to teach the very basic math skills using traditional methods and do not portray math as fun, exciting, and engaging to their students. According to Ashton & Webb (1982), mathematics self- efficacy reflects the confidence that teachers are adequately trained to teach mathematics or that teachers have enough experience to develop strategies for overcoming obstacles to student learning in the content area of mathematics. The results of the study seem to contradict Tschannen-Moran, Woolfolk- Hoy & Hoy (1998) study that showed that teachers with low mathematics self-efficacy tend to show little effort or motivation in planning mathematics lessons. They focus on a more traditional method of teaching, which often leads to poor student achievement. Mathematics teachers with low confidence do not provide opportunities for students to engage in real world tasks that would allow students to develop their mathematical confidence. Therefore, this negative perception and attitude of mathematics transfers to their students.

Low Expectations for Students.

All four teachers utilized traditional methods and procedures to teach mathematics. By using traditional methods in their mathematics instruction, the teachers set low expectations for students (Boaler, Williams, & Brown, 2000). The implementation of standards, either through Common Core State Standards-Mathematics (CCSS-M) or state standards based on the CCSS-M, provides opportunities for students to explore, investigate, discover, persevere in problem solving, communicate with peers, and critically assess mathematical strategies. These opportunities are vital for students to make the necessary connections and for conceptual understanding to occur. The triangulated data suggested that the four teachers felt like they were teaching the standards, however, the approach and methods the teachers chose seemed tell students that doing mathematics is simply working problems in a procedural manner. The MCOP^2 data revealed that there were no student centered activities in which the students could explore, investigate, and discover in order to make the necessary mathematical connections and build conceptual understanding, Also, all four participants agreed that their mathematics instruction is based on their students' prior knowledge and how much the students already understand. For example, teacher A stated, *"Prior knowledge of my students is the main factor in how I implement math instruction*." The four teachers assumed that the best way to teach students is by pre-deciding the work that their students were capable of doing and then teaching them accordingly. For example, teacher D stated, *"Students must know the basics before moving on to other skills."* Teachers that pre-decide the work that students learn send a fixed message to the students about their mathematical ability and potential. In turn, the students develop a fixed mindset and such mindsets impact student learning. These mindsets have been associated with low expectations and achievement (Blackwell, Trzesmiewski, & Dweck, 2007).

Teaching the Way I was Taught

Teaching the Way I was Taught Mathematics.

The four participants were all taught mathematics in a traditional way. The teacher was the person instructing and the students sat at desks listening, working problems, or taking notes. Teacher A discussed the fact that there was a lot of memorization. She stated *"I remember memorizing the order of the fact drills so I could finish quickly."* Teacher C discussed the fact that she had elementary teachers that instilled confidence in her and would not let her give up when she struggled to understand. However, she went on to state, *"that in high school she had teachers that didn't seem to care if you didn't understand."* She continued *"if I didn't get something when the teacher explained it, I was left to figure it our on my own."* Teacher D discussed the fact that her teachers *"would not allow you to move on to other skills until everyone in the class had mastered the skill they were on"* She continued *" I didn't have gaps in my learning like students do today."* Teacher B discussed the fact that the teachers she had just taught them the regular traditional way of memorizing algorithms. Because of the way she was taught, teacher B said, *"I do not understand how I am supposed to teach my students because I was never taught this new way."* All four participants discussed that when they were in school, *"their teachers would model concepts or skills to the class and work problems on the board as an example or guide."* Then, the students would work problems either on the board, from the textbook, or be given a worksheet to complete. The participants continued to discuss that the new way of teaching math oftentimes *"requires them to go home and study the concept or skill and teach themselves before they can prepare a lesson to teach the students."* The classroom observation data showed that the four participants teach mathematics the same way that they were taught mathematics. All four teachers modeled how to solve problems on the board using traditional approaches such as the standard algorithm. They assigned problems for the students to complete and then reviewed the answers with them.

How to Develop Mathematics Lessons

Professional Development.

It was evident that all four teachers had participated in professional development concerning mathematics instruction. All four teachers were able to discuss mathematics utilizing the best practices terminology and phrases. However, the two teachers that scored low on the MSES survey stated that they would like more professional development to feel comfortable with what they are supposed to teach in mathematics. Teacher B stated, *" I need more professional development in order to develop good lessons."* She continued to discuss the idea of having a mathematics coach do some side by side coaching with her to assist her in developing effective mathematical teaching skills. Teacher C also discussed the desire to have professional development. She stated, "*I need more professional development in order to feel better about the mathematics I am supposed to teach and how to teach it."*

On the other hand, the two teachers that scored high on the MSES survey did not mention professional development during their semi-structured interviews. However, the classroom observation data highlighted that while they feel comfortable teaching mathematics, they teach using traditional strategies and do not utilize best practices in their mathematics

instruction. This seems to suggest that the teachers scored themselves as being highly efficacious in mathematics because they felt confident in the mathematical skills being taught or mathematics in general and they felt comfortable with the way they were teaching the mathematical content. Pajares (1992) explained that knowledge of the subject is different than a feeling about teaching it, yet often the knowledge that one has impacts the feeling about teaching it. Furthermore, Kahle (2008) stated that teachers' mathematical teaching self-efficacy was related to teacher knowledge, teacher preparation, student achievement, personal efficacy, and vicarious experiences. If the teachers' experiences in mathematics all centered around the traditional methods of teaching mathematics, that is what the teachers know and feel comfortable with which would lead to high mathematics self efficacy scores. However, this practice does not advance the students' understanding of mathematical concepts.

Strategies Used to Teach Mathematics

Mathematical Strategies Used.

During the semi- structured interviews**,** the participants discussed the strategies that they used to teach mathematics. Teacher A discussed the fact that students should be active participants of their learning and that students learn better when they are doing and can manipulate things. She continued to discuss the fact that she uses *"a lot of hands on* *activities where students break into groups and work different tasks or problems related to the math skill being taught."* She stated that she introduces the skill to the whole class and they work problems together until she feels comfortable that the students have grasped the skill and then she allows the students to work in small groups or centers to reinforce the skill. While teacher A allowed students to be active participants in their learning by working in small groups or centers, the activities that were given to the students did not promote student discovery, investigation, or exploration that would allow students to develop conceptual understanding on their own. Instead, the activities served as means of reinforcing what teacher A had taught. Introducing new mathematics content is an area where an inquiry based approach should be a critical part of the mathematics instruction (Rogers, 2002). This is primarily because the approach allows teachers to become more of a facilitator allowing students to discover concepts and mathematical connections on their own which leads to conceptual understanding.

Teacher B also discussed that she teaches through the use of centers and one on one instruction. She explained that she sets up three math centers and students rotate through each center. The center activities all revolve around the math skill versus the mathematical concept being taught. Again, there were no opportunities for students to explore and investigate in order to develop conceptual understanding of the math skill being taught. Teacher B also pulls students who are struggling to work one on one with her on that particular mathematics skill.

Teacher C stated that she uses exploration as well as hands on activities during her mathematics instruction. She stated, *"I try to provide a variety of activities so that I keep all of my students interested and focused."* Again, the classroom observation data revealed that while teacher C provided opportunities for students to be active participants in their learning, the activities did not promote inquiry and exploration. Most of the activities revolved around worksheets that promoted a drill the skill approach.

Teacher D discussed the fact that she does not utilize centers a whole lot in her instruction. She stated that she teaches *"to the whole class."* She continued to explain that *"the students are the learners first and they must learn the basics."* She stated that she asks a lot of "why" questions and she knew that the student had mastered the skill being taught when "*they could teach it back to her."*

One last observation revealed by the classroom observations was the fact that all four teachers seemed to teach the mathematical skills in isolation versus teaching the mathematical concept. The classroom observations revealed that the teachers teach using traditional methods such as the standard algorithm. Using this approach, the teachers are teaching the students through complete isolation of other mathematical concepts that might be related. The message that the teachers are sending to the students is that there is one way to solve math problems and the math skills are not related or connected in any way.

Administrative Decisions

Time.

All four teachers stated that the amount of time that is allotted to teach mathematics is not enough. The teachers stated that they have sixty minutes to teach mathematics. Teacher A stated, "*I wish I had more time to complete hands on activities with the students."* Teacher B agreed by stating that *'I need more time to cover everything that needs to be covered in math."* All of the teachers discussed the fact that reading instruction tends to be a priority when administrators have to develop the master schedules for each grade level and teacher. They stated that while mathematics instruction is viewed as being important, their administrators and school district deem reading instruction a priority, therefore, more time is allocated for reading. They also discussed that reading instruction is protected instructional time. They explained that this means that during reading instruction, there are no interruptions. They continued to discuss that reading is the only subject that has protected instructional time. The teachers stated that they usually use the time allocated for science, or social studies at least one to two days a week to add additional time to their allocated mathematics time. They stated that this is the only way that they have to work around the scheduling issue. However, none of the teachers mentioned the idea of using an integrated teaching approach as a solution for the time issue. By utilizing an integrated teaching approach, the teachers could have solved the issue of having enough time without cutting other pertinent instruction.

Findings

Based upon the findings from the classroom observations, semi-structured interviews, and the comparison of quantitative and qualitative data, the hypothesis that elementary teachers with low mathematics anxiety and high mathematics self-efficacy do not use traditional strategies to teach mathematics instruction is not supported.

Summary

The purpose of research question one was to determine whether mathematics self-efficacy and/or mathematics anxiety contributed to the prediction of mathematics teaching self-efficacy. The results indicated that mathematics anxiety and mathematics self-efficacy are not good predictors of mathematics teaching self-efficacy. While mathematics self-efficacy and mathematics anxiety are good predictors according to the R^2 change, the standardized coefficients were not significant.

The purpose of research questions two and three was to determine if elementary mathematics teachers with low anxiety and high self-efficacy used best practices and strategies in their mathematics instruction. Data analysis indicated that elementary teachers with low mathematics anxiety and high mathematics self-efficacy still use a more traditional approach to mathematics instruction. The data further suggested that elementary mathematics teachers with low anxiety and high self efficacy are either not comfortable with the mathematics standards that they are required to teach because of the mathematics content or they do not know how to teach mathematics any other way than using traditional strategies. The next chapter will examine the implications of the data gathered during the study.

Chapter V.

DISCUSSION

Introduction

Mathematics anxiety, mathematics self-efficacy, mathematics teaching self-efficacy, and the instructional practices of elementary mathematics teachers are all topics that have been explored as individual constructs. Much of the literature has focused on how the constructs affect student achievement, gender, and pre-service teachers (Beilock et al., 2010; Furner & Duffy, 2002; Hackett & Betz, 1989; Hembree, 1990; Jackson & Leffingwell, 1999; Manigault, 1997; Pajares & Miller, 1995). The mathematics anxiety elementary teachers may exhibit, or their low sense of mathematical self-efficacy, may make them more reluctant to implement the mathematical instruction necessary for student mastery. By recognizing the factors that negatively influence teachers' mathematical instruction, efforts can be made toward alleviating them.

Previous findings supported that teachers' anxiety and beliefs toward mathematics can be communicated to students through instruction, or lack thereof, and may have a significant negative impact on students' mathematical experiences and attitudes (Hembree, 1990, Scarpello, 2007, Sherman & Christian, 1999). Peker & Ertekin, (2011) found that there was a link between mathematics anxiety and anxiety about teaching mathematics. Teachers who were afraid of doing mathematics were more likely to be afraid of teaching mathematics. They also found that it could lead to behaviors in the teacher that can be detrimental to the mathematics achievement in students.   According to Sloan (2010), teachers who reported a dislike of mathematics spent 50% less time teaching mathematics, and teachers with negative attitudes toward mathematics frequently relied more on teaching skills and facts while disregarding cognitive thought processes and mathematical reasoning which fostered feelings of anxiety in students. In order to gain a deeper understanding, a multiple methods study was conducted that explored whether elementary mathematics teachers' mathematics anxiety and/or mathematical efficacy predict their mathematical teaching efficacy. The study took place in a school system in rural southeast Alabama. The researcher recruited elementary teachers from the entire school district to represent diverse backgrounds and teaching practices. The 51 participants in the study were elementary mathematics teachers in grades one through six. Four participants were purposely selected based upon the survey results to conduct the classroom observations and semi-structured interviews. According to the survey results, there were no participants that scored both low anxiety and high efficacy, so I took the two teachers that scored the lowest in mathematics anxiety and the two teachers that scored highest in mathematics self-efficacy.

Discussion of Findings

Research Question 1

Research question one examined whether mathematics anxiety and/or mathematics self-efficacy predict mathematics teaching self-efficacy. The data from the *Revised Mathematics Anxiety Rating Scale* (R- MARS), the *Mathematics Self-Efficacy Scale* (MSES), and the *Mathematics Teaching Efficacy Beliefs Instrument* (MTEBI) were analyzed using hierarchical regression. Mathematics anxiety and mathematics self-efficacy were found to be good predictors of mathematics teaching self-efficacy according to the R^2 change; however, the standardized coefficients were not significant. The findings are paradoxical in nature and further research is needed.

The findings are in agreement with Kruger & Dunning's (1999) study that focused on the links between competence, metacognitive ability, and inflated self-assessments. Kruger & Dunning (1999) found that people overestimate themselves in their competence and ability. They found that this overestimation of competence and ability is due to their lack of metacognitive skills. Kruger & Dunning (1999) also found that improving a person's metacognitive skills also improved their accuracy of their self-reporting of their competence and ability. Kruger & Dunning's (1999) findings were true for both highly competent individual's as well as those individual's who were not as competent.

The findings are in disagreement with Swars et al., (2006) study that found that a relationship between teachers' level of mathematics anxiety and level of mathematics self-efficacy existed when measured among pre-service teachers and that students in these teachers' classes would be conditioned by the teachers' attitudes, beliefs, behaviors, and efficacies (Cornell, 1999). The research findings also disagree with Kahle's (2008) findings that teachers' mathematical teaching self-efficacy is related to teacher knowledge, teacher preparation, student achievement, personal efficacy, and vicarious experiences. A possible reason for the disagreement in findings might be teacher beliefs.

Research Question 2

Research question two explored whether elementary mathematics teachers with low anxiety and high mathematics self-efficacy use best practices in their mathematics instruction. The triangulation of data from the classroom observations and semi-structured interviews revealed that teachers with low anxiety did not consistently use best practices in their instruction and preferred using more traditional methods of teaching mathematics. The research findings were not consistent with studies from the literature. For example, Swars (2005) found that elementary teachers with low mathematics anxiety were highly efficacious mathematics teachers. Furthermore, Swars et al. (2006), Vinson (2001), and Hembree (1990) found that mathematically anxious teachers, rather than mathematics teachers with low anxiety, tend to employ traditional teaching strategies rather than collaborative strategies. They spend more time on whole group instruction rather than differentiated instruction. Mathematically anxious teachers, rather than mathematics teachers with low anxiety, rely heavily on mathematics textbooks to direct the instruction, rote memorization, teach for skills acquisition rather than conceptual understanding of mathematical concepts. They assign the same work to all students, rather than meeting the needs of diverse learners in the classroom by providing scaffolding or tiered instruction. They emphasize solving textbook problems and algorithmic problem solving (Alsup, 2003), rather than spending time on problem solving activities and linking mathematical concepts to the real world.

The data also revealed that the two teachers that scored high on the self-efficacy survey did not consistently use best practices in mathematics instruction. These findings are not consistent with studies from the literature. As noted in previous studies related to general teacher self efficacy, efficacious behaviors in teachers resulted in better discipline, effective classroom management, motivation among students, and increased student achievement (Hoy & Woolfolk, 1990; Pintrich & Schunk, 2002). According to Kahle (2008), these same results occurred when applied to mathematical teaching self-efficacy. Furthermore, Tschannen-Moran & Hoy (2001) found that teacher self-efficacy has been related to “teachers’ classroom behaviors, their openness to new ideas, and their attitudes toward teaching” (p.215). According to Coleman (2001), a teacher’s general teaching efficacy conveys a personal belief that the power of teaching influences student learning. Also, teachers who have high teaching efficacy take responsibility for student learning.

Research Question 3

Research question three explored how mathematics anxiety and mathematics self-efficacy impacted the strategies that elementary mathematics teachers used in their mathematics instruction. The triangulation of data from the semi-structured interviews as well as the classroom observations revealed major themes and subthemes. The major themes that emerged were (1) attitudes and beliefs about mathematics, (2) teaching the way I was taught, (3) how to develop mathematics lessons, (4) strategies used to teach mathematics, and (5) administrative decisions. Following is a summary of the major themes and subthemes data that emerged.

Attitudes and Beliefs about Mathematics

Mathematically self confident.

The observational and semi-structured interview data showed that the teachers with high self-efficacy have confidence with mathematics because of the approach they use to teaching mathematics. This confidence or attitude transfers to their students as they become successful at solving mathematical problems using traditional methods. However, the approach or method that the teachers used did not allow students to make the necessary connections to build conceptual understanding nor did it provide opportunities for students to problem solve and discover solutions for themselves. Tschannen-Moran, Woolfolk-Hoy, and Hoy (1998) stated, "Teacher efficacy is the teacher's belief in his/her capability to organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context" (p. 233). By designing mathematics lessons that focused on traditional methods of instruction, the teachers structured the context of the mathematics instruction to fit their efficacy and needs and not the needs of the students. Kahle (2008) also stated that if the teachers' experiences in mathematics all centered around the traditional methods of teaching mathematics, that is what the teachers know and feel comfortable with which would lead to high mathematics self efficacy scores.

Low confidence.

The data suggested that mathematics teachers with low confidence do not exude a positive attitude about mathematics to their students. They tend to teach the very basic math skills using traditional methods and do not portray math as fun, exciting, and engaging to their students. The findings agree with Tschannen-Moran, Woolfolk-Hoy &

Hoy (1998) research when they found that teachers with low mathematics self-efficacy tend to show little effort or motivation in planning mathematics lessons. They focus on a more traditional method of teaching, which often leads to poor student achievement. Mathematics teachers with low confidence do not provide opportunities for student to engage in real world tasks that would allow students to develop their mathematical confidence. Therefore, this negative perception and attitude of mathematics transfers to their students.

Low expectations of students.

The data revealed that four of the teachers utilized traditional methods and procedures to teach mathematics. By using traditional methods that focus on algorithms and procedures in their mathematics instruction, the teachers set low expectations for students (Boaler, Williams, & Brown, 2000). Czernaik (1990) reported that teachers with a high sense of mathematical self-efficacy use a variety of instructional strategies such as inquiry-based instruction and student-centered tasks. These teachers are willing to use manipulatives, try new instructional strategies, and become a facilitator of instruction in the classroom (Czerniak & Schriver, 1994; Iyer & Wang, 2013; Swars et al., 2007; Woolfolk-Hoy, Hoy, & Davis, 2009). Thus, teachers that score high in self-efficacy in teaching mathematics report that they support more student risk taking, use more inquiry-based learning, use more student-centered teaching strategies, attend to students' prior knowledge, support equity, and encourage collaboration between students and teachers (Ottmar, Rimm-Kaufman, Berry, & Larsen, 2013). Teachers with a low sense of self-efficacy are more likely to use a traditional approach to teaching, which include teacher-directed strategies such as direct instruction, teaching from the textbook, rote memorization, and a focus on basic procedural skills rather than concepts in mathematics. Teachers with low mathematical self-efficacy spent less time on problem solving, small-group instruction, and individualized instruction. (Trice & Ogden, 1986). Possible reasons that the results differ from the literature include individual teacher beliefs, lack of system wide ownership of mathematics instruction by the teachers and principals, and lack of understanding of what inquiry based instruction really means.

Teaching the Way I was Taught

Teaching the way I was taught mathematics.

The data suggested that the four participants teach mathematics the same way that they were taught mathematics. The four participants were all taught mathematics using traditional methods and strategies. They discussed that they would learn to work math problems by watching the teacher solve problems using steps and procedures. After they had watched the teacher work a few problems, then the class would be assigned a few problems to work for practice. All four teachers seemed to use this same approach of teaching mathematics as they were taught because during the classroom observations, they modeled how to solve problems on the board using traditional approaches such as the standard algorithm. They would assign problems for the students to complete and then reviewed the answers with them. Ball & Forzani (2009) suggested that for many elementary mathematics teachers, knowing math had always meant being able to produce the answer that their teacher wanted using the standard algorithm and paying close attention to the step by step procedures that they took to get the answer. Kahle (2008) also stated that if the teachers' experiences in mathematics all centered around the traditional methods of teaching mathematics, that is what the teachers know and feel comfortable with which would lead to high mathematics self efficacy scores.

How to Develop Mathematics Lessons

Professional development.

The data revealed that all four teachers had participated in professional development concerning mathematics instruction. All four teachers were able to discuss mathematics utilizing the best practices terminology and phrases. However, the two teachers that scored low on the MSES survey stated that they would like more professional development to feel comfortable with what they are supposed to teach in mathematics. Specifically, teacher B stated that she would like to have a mathematics coach come in and work with her using some side-by-side coaching.

On the other hand, the two teachers that scored high on the MSES survey did not mention professional development during their semi-structured interviews. However, the classroom observations indicated that while they feel comfortable teaching mathematics, they teach using traditional strategies and did not utilize best practices in their mathematics instruction. This seemed to suggest that the teachers scored themselves as being highly efficacious in mathematics because they felt confident in the mathematical skills being taught or mathematics in general and they felt comfortable with the way they were teaching the mathematical content. Pajares (1992) explained that knowledge of the subject is different than a feeling about teaching it, yet often the knowledge that one has impacts the feeling about teaching it. Furthermore, Kahle (2008) stated that teachers' mathematical teaching self-efficacy was related to teacher knowledge, teacher preparation, student achievement, personal efficacy, and vicarious experiences. Possible reasons that the findings differed from the literature include teachers not buying-in to inquiry-based instruction, lack of system-wide support, lack of principal support, and lack of teacher planning and preparation.

Strategies Used to Teach Mathematics

Mathematical strategies used.

All four of the teachers were able to use the correct mathematical terminology when discussing the strategies that they used in their mathematics instruction. They discussed that students should be active participants of their learning and that they should participate in hands –on activities that allowed the students to explore. However, the classroom observations revealed something completely different. The observations showed that the teachers used centers and group work, but it was extremely controlled by the teacher. The students usually were working on review skills or a worksheet using traditional methods. There were no opportunities for students to explore the mathematical skill on their own and make connections in order to build conceptual understanding. Possible reasons for this are that the teachers are just using the mathematical language that they have heard used at previous professional development sessions they have attended and really do not know what the language means in terms of mathematics instruction, or the teachers do not want to relinquish the control of the classroom and continue to utilize a teacher centered approach when they think that they are teaching mathematics from a inquiry based approach.

Rather than using a traditional approach to teaching mathematics, Bush (2006) and Rogers (2002) recommended using an inquiry based approach as it allows the mathematics teacher to teach directly during critical points in the lesson, but it allows students to discover and develop their own understanding of the mathematical concept being taught. The inquiry based learning approach supports a problem solving process that allows students to utilize deeper levels of understanding beyond what traditional approaches have accomplished (Goodrow, 2007; NCTM, 2000).

Administrative Decisions

Time.

The four teachers stated that the amount of time that is allotted to teach mathematics is not enough. The teachers stated that they have 60 minutes to teach mathematics. They stated that while mathematics instruction is viewed as being important, their administrators and school district deem reading instruction a priority, They also discussed that reading instruction is protected instructional time. The teachers state that they usually use the time allocated for science, or social studies at least one to two days a week to add additional time to their allocated mathematics time. They stated that this is the only way that they have to work around the scheduling issue. However, none of the teachers mentioned the idea of using an integrated teaching approach as a solution for the time issue. By utilizing an integrated teaching approach, the teachers could have solved the issue of having enough time without cutting other pertinent instruction.

Implications for Practice

The findings of this study have clear implications for mathematics education and specifically elementary mathematics teachers. The findings indicate that there is an inconsistency among teachers' mathematical teaching efficacy and the instructional practices that they utilize in their mathematics instruction. This inconsistency seems to indicate that either the teachers do not understand what it means to teach mathematics using best practice based instruction or they do not feel confident enough to teach mathematics using these practices. Because of this inconsistency, there is a need for additional support to help elementary mathematics teachers overcome the anxiety and/or lack of self-efficacy in order to foster best practices in mathematics instruction.

Efforts should be made to help students learn the more complex and analytical skills they need to be successful in today's society. Teachers must learn to teach in ways that help students develop higher-order thinking skills and be able to apply those skills to solve real world problems. To develop this form of teaching, education systems must offer more effective professional development than traditionally has been available. Research on professional development has shown that there is a paradigm shift, one that rejects the ineffective "drive-by" workshop model of the past in favor of more powerful opportunities (Stein, Smith, & Silver, 1999).

The content of professional development can make a difference in enhancing teachers' mathematical competence and lowering mathematical fears and anxiety. The most useful professional development emphasizes active teaching, assessment, observation, and reflection rather than abstract discussions (Darling-Hammond & McLaughlin, 1995). Professional development that focuses on student learning and helps teachers develop the pedagogical skills to teach specific kinds of content has strong positive effects on practice (Blank, de las Alas, & Smith, 2007; Wenglinsky, 2000). Research on effective professional development also highlights the importance of collaborative and collegial learning environments that help develop communities of learning and be able to promote school change beyond individual classrooms (Darling-

Hammond & McLaughlin, 1995; Hord, 1997; Knapp, 2003; Louis, Marks, & Kruse, 1996; Perez et al., 2007).

Professional development experiences must also address how teachers learn. In particular, active learning opportunities allow teachers to transform their teaching and not simply layer new strategies on top of the old (Snow-Renner & Lauer, 2005). These opportunities often involve modeling the new strategies and constructing opportunities for teachers to practice and reflect on them (Garet et al., 2001; Saxe, Gearhart, & Nasir, 2001; Supovitz, Mayer, & Kahle, 2000). In addition, teaching practices and student learning are more likely to be transformed by professional development that is sustained, coherent, and intense (Cohen & Hill, 2001; Garet et al, 2001; Supovitz et al., 2000; Weiss & Pasley, 2006). The traditional episodic, fragmented approach does not allow for rigorous, cumulative learning (Knapp, 2003).

The findings of this study also indicated that efforts should be made at the higher education level to assist elementary pre-service teachers become better prepared in teaching mathematics using best practices in instruction. Currently, the focus of mathematics education is to teach mathematics from a conceptual standpoint (Kahle, 2008). If elementary mathematics teachers are to teach from this conceptual standpoint, then, they must have a strong mathematics foundation as well as a strong mathematics teaching self-efficacy. Mathematics educators should assist pre-service teachers in building a firm understanding of the mathematical content during the pre-service teachers foundational mathematics courses. Mathematics educators can plan experiences in the methods courses that allow the pre-service teachers to reinforce these mathematical concepts and skills through participation in inquiry based activities that allow them to make connections through exploration and investigation. Additionally, pre-service teachers need opportunities to practice what they have learned through teaching instructional lessons in a safe environment that will allow them to receive constructive feedback and build their self- efficacy. Ball & Forzani (2011) stated that predictable routines in which pre-service teachers present mathematics problems as well as lead instructional conversations must be taught and practiced within teacher education programs in order for pre-service teachers to become comfortable, confident, and successful.

Another way to provide opportunities for pre-service teachers to make connections between the mathematics methods course and the elementary mathematics classroom is through extensive field experiences. These experiences allows the pre-service teachers to practice what they have been taught, including designing lesson plans that promote best practices, in a real life classroom setting and receive invaluable feedback from the practicing classroom teacher. However, if the practicing classroom teacher doesn’t teach mathematics using an inquiry- based approach, the pre-service teacher should be provided opportunities for mentoring and induction in the elementary mathematics classroom.

Recommendations for Future Research

While extensive research on mathematics anxiety and self-efficacy has been conducted, the focus has been on how the constructs affect student achievement, gender, or pre-service teachers. There is a need for more research involving teachers’ mathematics anxiety, mathematical self-efficacy, mathematical teaching self-efficacy, and the instructional practices of elementary school teachers. There exists a gap in the literature regarding the relationship and interconnectedness among the constructs. Also, previous literature has suggested that personal and external factors relating to teachers' mathematics instructional practices should be further researched (Brown, 2005). The following are recommendations for future research.

1. The current study should be replicated with a larger sample size so that generalizability and transferability are not limited.
2. Further study should also be conducted that focuses on the impact of elementary mathematics teachers on student learning.
3. Future study should be conducted on the coping strategies of teachers with low confidence.
4. Future study should be conducted on the relationship between elementary mathematics teachers and student enthusiasm.
5. Future study should be conducted on elementary mathematics teachers who are successfully teaching mathematics using inquiry based or problem based approaches.
6. Further study should be conducted with pre-service teachers with high mathematics anxiety and low mathematical self-efficacy.

Conclusion

The purpose of this study was to explore whether elementary mathematics teachers' mathematics anxiety and/or mathematical efficacy predict their mathematical teaching efficacy. The study also explored whether elementary mathematics teachers with low anxiety and high mathematics self-efficacy utilized best practices in their mathematics instruction. The findings of this study do not support much of the previous literature on the topics. The results of the quantitative data showed paradoxical findings. The R^2 change showed that mathematics anxiety and mathematics self-efficacy were both good predictors of mathematics teaching self-efficacy, however, the findings of the qualitative data showed that teachers with low anxiety and high self-efficacy utilize traditional methods in their mathematics instruction.

The most effective mathematics practices can be promoted by identifying the possible relationship between the constructs of mathematics anxiety, mathematics self-efficacy, and mathematics teaching self-efficacy. It is imperative as educators that we assist pre-service and practicing teachers in alleviating their mathematics anxiety and change their mathematical beliefs so that they can design mathematics instruction that utilizes best practices which will, in turn, lead to students learning mathematics conceptually.

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Appendix A

Consent Form

COLLEGE OF EDUCATION

CURRICULUM & TEACHING

AUBURN
UNIVERSITY

(NOTE: DO NOT SIGN THIS DOCUMENT UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMED CONSENT
For a Research Study entitled
"Mathematics Anxiety and Mathematics Self-Efficacy as Predictors of Mathematics Teaching Self-Efficacy"

6/24/15 6/23/16
15-264 EP 1506

You are invited to participate in a research study to determine if mathematics anxiety and mathematics self-efficacy are good predictors of mathematics teaching self-efficacy. The study is being conducted by Lisa Etheridge, doctoral student, under the direction of Dr. Deborah Morowski, Associate Professor in the Auburn University Department of Curriculum and Teaching. You were selected as a possible participant because you are an elementary mathematics teacher and are age 19 or older.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to complete three surveys concerning your thoughts about mathematics. You may also be asked to participate in one classroom observation that will not be audio or video recorded and will focus on the mathematical strategies you implement in your classroom. As well, you may also be asked to participate in one semi structured interview concerning mathematics that will be audio recorded for transcription purposes only. Your total time commitment will be approximately three hours.

HALEY CENTER
AUBURN, AL

TELEPHONE:

FAX:

Are there any risks or discomforts? The risk associated with participating in this study is the potential for breach of confidentiality. To minimize these risks, we will code all identifiable data collected and the master code list will be kept in a folder in a locked file cabinet in the researcher's personal residence.

Are there any benefits to yourself or others? There is no direct benefit to you as a participant in this study.

Participant's initials ______ Page 1 of 3

Appendix A

Consent Form

6/24/15 to 6/23/16

15-254 EP 1506

Will you receive compensation for participating? No compensation for participating will be given to participants.

Are there any costs? There will be no cost involved for participating in the research study.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Curriculum and Teaching or the Elmore County Board of Education.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation may be used to fulfill an educational requirement, publish in a professional journal, or present at a professional conference or meeting.

If you have questions about this study, please ask them now or contact Lisa Etheridge at 334-538-8727 or Dr. Deborah Morowski at 334-844-6796. A copy of this document will be given to you to keep.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334) 844-5966 or email at IRBadmin@auburn.edu or IRBChair@auburn.edu.

Participant's initials ____ Page 2 of 3

Appendix A

Consent Form

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

PARTICIPANT'S SIGNATURE DATE

PRINTED NAME

INVESTIGATOR OBTAINING CONSENT DATE

PRINTED NAME

Page 3 of 3

Appendix B

Mathematics Anxiety Rating Scale Revised

Mathematics Anxiety Rating Scale Revised

For each statement below circle the response that characterizes the level of anxiety you experience.

1=no anxiety 2= some anxiety 3= moderate anxiety 4= high anxiety 5= extreme anxiety

1. Taking an examination (final) in a mathematics course	1	2	3	4	5
2. Thinking about an upcoming mathematics test one week before	1	2	3	4	5
3. Thinking about an upcoming mathematics test one day before	1	2	3	4	5
4. Thinking about an upcoming mathematics test one hour before	1	2	3	4	5
5. Thinking about an upcoming mathematics test five minutes before	1	2	3	4	5
6. Waiting to get a mathematics test returned in which you expected to do well	1	2	3	4	5
7. Receiving your final mathematics grade in the mail	1	2	3	4	5
8. Realizing that you have to take a number of mathematics classes to fulfill the requirements in your major	1	2	3	4	5
19. Being given a "pop" quiz in a mathematics class	1	2	3	4	5
10. Studying for a mathematics test	1	2	3	4	5
11. Taking the mathematics section of a college entrance exam	1	2	3	4	5
12. Taking an examination (quiz) in a mathematics course	1	2	3	4	5
13. Picking up the mathematics textbook to begin working on a homework assignment	1	2	3	4	5
14. Being given a homework assignment of many difficult problems which is due the next class meeting	1	2	3	4	5
15. Getting ready to study for a mathematics test	1	2	3	4	5
16. Dividing a five digit number by a two digit number in private with pencil and paper	1	2	3	4	5
17. Adding 976 + 777 on paper	1	2	3	4	5
18. Reading a cash register receipt	1	2	3	4	5
19. Figuring the sales tax on a purchase that costs more than $1.00	1	2	3	4	5
20. Figuring out your monthly budget	1	2	3	4	5
21. Being given a set of numerical problems involving addition to solve on paper	1	2	3	4	5
22. Having someone watch you as you total up a column of figures	1	2	3	4	5

Appendix B

Mathematics Anxiety Rating Scale Revised

23. Totaling up a dinner bill that you think overcharged you	1	2	3	4	5
24. Being responsible for collecting dues for an organization and keeping track of the amount	1	2	3	4	5
25. Studying for a drivers license test and memorizing the figures involved, such as the distances it takes to stop a car going different speeds	1	2	3	4	5
26. Totaling up the dues received and the expenses of a club you belong to	1	2	3	4	5
27. Watching someone work with a calculator	1	2	3	4	5
28. Being given a set of division problems to solve	1	2	3	4	5
29. Being given a set of subtraction problems to solve	1	2	3	4	5
30. Being given a set of multiplication problems to solve	1	2	3	4	5

Appendix C

Mathematics Self-Efficacy Survey

For use by Lisa Etheridge only. Received from Mind Garden, Inc.

mind garden

www.mindgarden.com

To whom it may concern,

This letter is to grant permission for the above named person to use the following copyright material;

Instrument: ***Mathematics Self-Efficacy Scale***

Authors: ***Nancy E. Betz & Gail Hackett***

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for his/her thesis research.

Five sample items from this instrument may be reproduced for inclusion in a proposal, thesis, or dissertation.

The entire instrument may not be included or reproduced at any time in any other published material.

Sincerely,

Robert Most
Mind Garden, Inc.
www.mindgarden.com

Appendix C

Mathematics Self-Efficacy Survey

Name or I.D.____

Part I

No Confidence at all	Very little Confidence			Some Confidence		Much Confidence		Complete Confidence	
0	1	2	3	4	5	6	7	8	9

How much confidence do you have that you could successfully:

1. Add two large numbers (e.g., 5379 + 62543) in your head..........	0	1	2	3	4	5	6	7	8	9
2. Determine the amount of sales tax on a clothing purchase.	0	1	2	3	4	5	6	7	8	9
3. Figure out how much material to buy in order to make curtains..........	0	1	2	3	4	5	6	7	8	9
4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 3/4% interest.	0	1	2	3	4	5	6	7	8	9
5. Multiply and divide using a calculator.	0	1	2	3	4	5	6	7	8	9

Appendix D

Mathematics Teaching Efficacy Beliefs Instrument

Mathematics Teaching Efficacy Beliefs Instrument

Please indicate the degree to which you agree or disagree with each statement below by circling the appropriate letters to the right of each statement.

SA= Strongly Agree **A**= Agree **UN**= Uncertain **D**= Disagree **SD**= Strongly Disagree

Statement	SA	A	UN	D	SD
1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	1	2	3	4	5
2. I will continually find better ways to teach mathematics	1	2	3	4	5
3. Even if I try very hard, I will not teach mathematics as well as I will most subjects.	1	2	3	4	5
4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	1	2	3	4	5
5. I know how to teach mathematics concepts effectively.	1	2	3	4	5
6. I am not very effective in monitoring mathematics activities	1	2	3	4	5
7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	1	2	3	4	5
8. I will generally teach mathematics ineffectively.	1	2	3	4	5
9. The inadequacy of a student's mathematics background can be overcome by good teaching	1	2	3	4	5

Appendix D

Mathematics Teaching Efficacy Beliefs Instrument

10. When a low achieving child progresses in mathematics, it is usually due to extra attention given by the teacher	1	2	3	4	5
11. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	1	2	3	4	5
12. The teacher is generally responsible for the achievement of students in mathematics.	1	2	3	4	5
13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	1	2	3	4	5
14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	1	2	3	4	5
15. I find it difficult to use manipulatives to explain to students why mathematics works.	1	2	3	4	5
16. I typically am able to answer students' questions.	1	2	3	4	5
17. I wonder if I have the necessary skills to teach mathematics.	1	2	3	4	5
18. Given a choice, I would not invite the principal to evaluate my mathematics teaching.	1	2	3	4	5
19. When a student has difficulty understanding a mathematics concept, I am usually at a loss as to how to help the student understand it better.	1	2	3	4	5
20. When teaching mathematics, I usually welcome students' questions.	1	2	3	4	5
21. I do not know what to do to turn students on to mathematics.	1	2	3	4	5

Appendix E

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

On Nov 2, 2015, at 8:51 PM, Zelkowski, Jeremy <jzelkowski@ua.edu> wrote:

I think that would be great. I'll send you the info tomorrow morning.

Jeremy Zelkowski
Associate Professor
Secondary Math Education
The University of Alabama
President, ACTM
T3 National Instructor

Sent via the Samsung Galaxy Note® 4, an AT&T 4G LTE smartphone

-------- Original message --------
From: Lisa Etheridge <lfe0001@tigermail.auburn.edu>
Date: 11/2/2015 6:14 PM (GMT-06:00)
To: "Zelkowski, Jeremy" <jzelkowski@ua.edu>
Subject: Question

Dr. Zelkowski:
My name is Lisa Etheridge and I am a doctoral student at Auburn University. Dr. Burton and Dr. Strutchens suggested that I email you to seek your opinion on using the MCOP2 observation instrument to conduct classroom observations of mathematics instruction at the elementary level. I would like to include classroom observations as part of my data for my dissertation. I look forward to hearing your thoughts.

Sincerely,
Lisa

Lisa Etheridge

Appendix E

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

1) Students engaged in exploration/investigation/problem solving.

Score	Description	Comments
3	Students regularly engaged in exploration, investigation, or problem solving. Over the course of the lesson, the majority of the students engaged in exploration/investigation/problem solving.	
2	Students sometimes engaged in exploration, investigation, or problem solving. Several students engaged in problem solving, but not the majority of the class.	
1	Students seldom engaged in exploration, investigation, or problem solving. This tended to be limited to one or a few students engaged in problem solving while other students watched but did not actively participate.	
0	Students did not engage in exploration, investigation, or problem solving. There were either no instances of investigation or problem solving, or the instances were carried out by the teacher without active participation by any students.	

2) Students used a variety of means (models, drawings, graphs, concrete materials, manipulatives, etc.) to represent concepts.

Score	Description	Comments
3	The students manipulated or generated two or more representations to represent the same concept, and the connections across the various representations, relationships of the representations to the underlying concept, and applicability or the efficiency of the representations were explicitly discussed by the teacher or students, as appropriate.	
2	The students manipulated or generated two or more representations to represent the same concept, but the connections across the various representations, relationships of the representations to the underlying concept, and applicability or the efficiency of the representations were **not** explicitly discussed by the teacher or students.	
1	The students manipulated or generated one representation of a concept.	
0	There were either no representations included in the lesson, or representations were included but were exclusively manipulated and used by the teacher. If the students only watched the teacher manipulate the representation and did not interact with a representation themselves, it should be scored a 0.	

3) Students were engaged in mathematical activities.

Score	Description	Comments
3	Most of the students spend two-thirds or more of the lesson engaged in mathematical activity at the appropriate level for the class. It does not matter if it is one prolonged activity or several shorter activities. (Note that listening and taking notes does not qualify as a mathematical activity unless the students are filling in the notes and interacting with the lesson mathematically.)	
2	Most of the students spend more than one-quarter but less than two-thirds of the lesson engaged in appropriate level mathematical activity. It does not matter if it is one prolonged activity or several shorter activities.	
1	Most of the students spend less than one-quarter of the lesson engaged in appropriate level mathematical activity. There is at least one instance of students' mathematical engagement.	
0	Most of the students are not engaged in appropriate level mathematical activity. This could be because they are never asked to engage in any activity and spend the lesson listening to the teacher and/or copying notes, or it could be because the activity they are engaged in is not mathematical – such as a coloring activity.	

4) Students critically assessed mathematical strategies.

Score	Description	Comments
3	More than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.	
2	At least two but less than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.	
1	An individual student critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher. The critical assessment was limited to one student.	
0	Students did not critically assess mathematical strategies. This could happen for one of three reasons: 1) No strategies were used during the lesson; 2) Strategies were used but were not discussed critically. For example, the strategy may have been discussed in terms of how it was used on the specific problem, but its use was not discussed more generally; 3) Strategies were discussed critically by the teacher but this amounted to the teacher telling the students about the strategy(ies), and students did not actively participate.	

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Appendix E

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

5) Students persevered in problem solving.

Score	Description	Comments
3	Students exhibited a strong amount of perseverance in problem solving. The majority of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), the majority of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem.	
2	Students exhibited some perseverance in problem solving. Half of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), half of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem.	
1	Students exhibited minimal perseverance in problem solving. At least one student but less than half of students looked for entry points and solution paths, monitored and evaluated progress, and changed course if necessary. When confronted with an obstacle (such as how to begin or what to do next), at least one student but less than half of students continued to use resources (physical tools as well as mental reasoning) to continue to work on the problem. There must be a road block to score above a 0.	
0	Students did not persevere in problem solving. This could be because there was no student problem solving in the lesson, or because when presented with a problem solving situation no students persevered. That is to say, all students either could not figure out how to get started on a problem, or when they confronted an obstacle in their strategy they stopped working.	

6) The lesson involved fundamental concepts of the subject to promote relational/conceptual understanding.

Score	Description	Comments
3	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, and the teacher/lesson uses these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.	
2	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, but the teacher/lesson misses several opportunities to use these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.	
1	The lesson mentions some fundamental concepts of mathematics, but does not use these concepts to develop the relational/conceptual understanding of the students. For example, in a lesson on the slope of the line, the teacher mentions that it is related to ratios, but does not help the students to understand how it is related and how that can help them to better understand the concept of slope.	
0	The lesson consists of several mathematical problems with no guidance to make connections with any of the fundamental mathematical concepts. This usually occurs with a teacher focusing on procedure of solving certain types of problems without the students understanding the "why" behind the procedures.	

7) The lesson promoted modeling with mathematics.

Score	Description	Comments
3	Modeling (using a mathematical model to describe a real-world situation) is an integral component of the lesson with students engaged in the modeling cycle (as described in the Common Core State Standards).	
2	Modeling is a major component, but the modeling has been turned into a procedure (i.e. a group of word problems that all follow the same form and the teacher has guided the students to find the key pieces of information and how to plug them into a procedure.); <u>or</u> modeling is not a major component, but the students engage in a modeling activity that fits within the corresponding standard of mathematical practice.	
1	The teacher describes some type of mathematical model to describe real-world situations, but the students do not engage in activities related to using mathematical models.	
0	The lesson does not include any modeling with mathematics.	

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Appendix E

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

8) The lesson provided opportunities to examine mathematical structure. (symbolic notation, patterns, generalizations, conjectures, etc.)

Score	Description
3	The students have a sufficient amount of time and opportunity to look for and make use of mathematical structure or patterns.
2	Students are given some time to examine mathematical structure, but are not allowed adequate time or are given too much scaffolding so that they cannot fully understand the generalization.
1	Students are shown generalizations involving mathematical structure, but have little opportunity to discover these generalizations themselves or adequate time to understand the generalization.
0	Students are given no opportunities to explore or understand the mathematical structure of a situation.

Comments

9) The lesson included tasks that have multiple paths to a solution or multiple solutions.

Score	Description
3	A lesson which includes several tasks throughout; or a single task that takes up a large portion of the lesson; with multiple solutions and/or multiple paths to a solution and which increases the cognitive level of the task for different students.
2	Multiple solutions and/or multiple paths to a solution are a significant part of the lesson, but are not the primary focus, or are not explicitly encouraged; <u>or</u> more than one task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.
1	Multiple solutions and/or multiple paths minimally occur, and are not explicitly encouraged; <u>or</u> a single task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.
0	A lesson which focuses on a single procedure to solve certain types of problems and/or strongly discourages students from trying different techniques.

Comments

10) The lesson promoted precision of mathematical language.

Score	Description
3	The teacher "attends to precision" in regards to communication during the lesson. The students also "attend to precision" in communication, or the teacher guides students to modify or adapt non-precise communication to improve precision.
2	The teachers "attends to precision" in all communication during the lesson, but the students are not always required to also do so.
1	The teacher makes a few incorrect statements or is sloppy about mathematical language, but generally uses correct mathematical terms.
0	The teacher makes repeated incorrect statements or incorrect names for mathematical objects instead of their accepted mathematical names.

Comments

11) The teacher's talk encouraged student thinking.

Score	Description
3	The teacher's talk focused on **high levels** of mathematical thinking. The teacher may ask lower level questions within the lesson, but this is not the focus of the practice. There are three possibilities for high levels of thinking: analysis, synthesis, and evaluation. ***Analysis*** : examines/ interprets the pattern, order or relationship of the mathematics; parts of the form of thinking. **Synthesis**: requires original, creative thinking. **Evaluation**: makes a judgment of good or bad, right or wrong, according to the standards he/she values.
2	The teacher's talk focused on **mid-levels** of mathematical thinking. **Interpretation**: discovers relationships among facts, generalizations, definitions, values and skills. **Application**: requires identification and selection and use of appropriate generalizations and skills
1	Teacher talk consists of **"lower order"** knowledge based questions and responses focusing on recall of facts. **Memory**: recalls or memorizes information. **Translation**: changes information into a different symbolic form or situation.
0	Any questions/ responses of the teacher related to mathematical ideas were rhetorical in that there was no expectation of a response from the students.

Comments

12) There were a high proportion of students talking related to mathematics.

Score	Description
3	More than three quarters of the students were talking related to the mathematics of the lesson at some point during the lesson.
2	More than half, but less than three quarters of the students were talking related to the mathematics of the lesson at some point during the lesson.
1	Less than half of the students were talking related to the mathematics of the lesson.
0	No students talked related to the mathematics of the lesson.

Comments

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Appendix E

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

13) There was a climate of respect for what others had to say.

Score	Description
3	**Many** students are sharing, questioning, and commenting during the lesson, including their struggles. Students are also listening (active), clarifying, and recognizing the ideas of others.
2	The environment is such that **some** students are sharing, questioning, and commenting during the lesson, including their struggles. Most students listen.
1	Only a **few** share as called on by the teacher. The climate supports those who understand or who behave appropriately. **Or** Some students are sharing, questioning, or commenting during the lesson, but most students are actively listening to the communication.
0	No students shared ideas.

Comments

14) In general, the teacher provided wait-time.

Score	Description
3	The teacher **frequently** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.
2	The teacher **sometimes** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.
1	The teacher **rarely** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.
0	The teacher **never** provided an ample amount of "think time" for the depth and complexity of a task or question posed by either the teacher or a student.

Comments

15) Students were involved in the communication of their ideas to others (peer-to-peer).

Score	Description
3	**Considerable** time **(more than half)** was spent with peer to peer dialog (pairs, groups, whole class) related to the communication of ideas, strategies and solution.
2	**Some** class time **(less than half, but more than just a few minutes)** was devoted to peer to peer (pairs, groups, whole class) conversations related to the mathematics.
1	The lesson was primarily teacher directed and little opportunities were available for peer to peer (pairs, groups, whole class) conversations. A few instances developed where this occurred during the lesson but only lasted less than 5 minutes.
0	No peer to peer (pairs, groups, whole class) conversations occurred during the lesson.

Comments

16) The teacher uses student questions/comments to enhance conceptual mathematical understanding.

Score	Description
3	The teacher **frequently** uses student questions/ comments to coach students, to facilitate conceptual understanding, and boost the conversation. The teacher sequences the student responses that will be displayed in an intentional order, and/or connects different students' responses to key mathematical ideas.
2	The teacher **sometimes** uses student questions/ comments to enhance conceptual understanding.
1	The teacher **rarely** uses student questions/ comments to enhance conceptual mathematical understanding. The focus is more on procedural knowledge of the task verses conceptual knowledge of the content.
0	The teacher **never** uses student questions/ comments to enhance conceptual mathematical understanding.

Comments

Additional Notes: Preservice or Inservice. Live or Video. #Students, Grade Level, topic/subject, date, other demographics, school, etc.

Appendix F

Code List

Code List

Codes
Feeling about teaching math
Strategies used to teach math
Subjects taught
How I was taught math
Attitude about math
Beliefs about math
Years of experience
Professional development completed in math

Appendix G

Semi Structured Interview Protocol

Semi- Structured Interview Protocol

1. How many years experience do you have teaching?
2. What is your background? Where did you attend college? Degrees you hold?
3. What grades have you taught?
4. What subjects do you teach?
5. How do you feel about math in general?
6. How do you feel about teaching math?
7. How do you feel when you hear the word "mathematics"?
8. What do you think about when you hear the word "mathematics"?
9. What is your view on mathematics?
10. What is your view about teaching mathematics?
11. In terms of anxiety or feeling anxious about mathematics, how would you rate yourself with 1 being not anxious at all and 10 being extremely anxious? Why?
12. In terms of confidence about mathematics, how would you rate yourself with 1 being very confident and 10 being not confident at all? Why?
13. What do you think contributed to your anxiety about mathematics? (if applicable)
14. What do you think contributed to your confidence or lack of confidence in mathematics?
15. Did you like math when you were in school?
16. How did your math teachers teach you math?
17. What do you remember best about learning math in school?
18. Tell me about your worst experience in a mathematics class.
19. How could this situation been made positive for you?
20. What does an ideal mathematics classroom look like?
21. What is the role of a mathematics teacher?

Appendix G

Semi Structured Interview Protocol

22. What is the role of a student learning math?
23. How do you think children learn math concepts the best?
24. What types of questions are important to ask in a math class? Why?
25. How has your personal experiences with math influenced your math instruction?
26. What factors have had a major impact on how your design and implement math instruction?
27. Do you think your attitudes and beliefs about math influence your math instruction? Why?
28. If you could change anything about your math instruction, what would it be ad why?
29. How does teaching math make you feel?
30. Is there anything else you would like to discuss that we have talked about?