UNDERSTANDING MATHEMATICS ANXIETY: THE RELATIONSHIPS BETWEEN FOURTH GRADE STUDENTS’ MATH ANXIETY, MULTIPLICATION FACT FLUENCY, AND PROBLEM SOLVING ABILITY

by

Julie Anne Dutko

Liberty University

A Dissertation Presented in Partial Fulfillment Of the Requirements for the Degree Doctor of Education

Liberty University

2015
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APPROVED BY: 

Nathan Putney, Ed.D., Committee Chair 
Elizabeth Hillman, Ph.D., Committee Member 
Xianqoin Yang, Ed.D., Committee Member 
Scott Watson, Ph.D., Associate Dean, Advanced Programs
ABSTRACT

The necessity of math skills is evident in everyday life, as well as job-specific tasks. Unfortunately, math anxiety has become a growing problem among people of all ages. Understanding more about potential indicators or predictors of math anxiety at a young age may help alleviate some of the impacts math anxiety has on mathematics achievement throughout life. This study considered the relationships between mathematics anxiety, multiplication fact fluency, math problem solving ability, math confidence, prior achievement, and demographic variables of fourth grade students. Fourth grade students at two suburban elementary schools in North Georgia were surveyed about their math anxiety using the Math Anxiety Scale for Children (MASC). Math confidence was measured by a subscale of the Attitudes toward Math Inventory (ATMI). They also demonstrated their multiplication fact fluency and problem solving fluency using grade level monitoring probes. The results of the study were used to specifically determine if multiplication fact fluency has a predictive relationship with mathematics anxiety.

Keywords: math anxiety, math achievement, elementary, math confidence, hierarchical regression, multiplication fluency, predictive correlation, math attitudes, gender
Acknowledgments

I would like to first give thanks to my personal Lord and Savior, Jesus Christ. From beginning to end, He supplied me with precisely what was needed in His time, not my own. These provisions were not always what I expected, planned, or asked for, but in the end His perfect plan for this process is clear. I believe that God was answering my prayers and strengthening me with just what I needed when I needed it throughout this process. When I was weak, tired, frustrated, or ready to give up, I was given the supernatural strength to carry on.

Next, I want to thank my wonderful husband. Phil, you are an amazing partner and my very best friend. Thank you for allowing me and encouraging me to do this even though I know you thought it was totally crazy! You have sacrificed so much of yourself to take great care of our family. You are such an incredible example, to me and the girls, of what sacrificial love looks like. You are unquestionably the best husband and daddy around. Thank you for not only understanding the time commitment this would be, but also for encouraging me all the way. Your confidence in me makes believe that I can actually accomplish anything. I admire your incredible leadership and humility. To Kori and Molly, my precious girls, I love you! Thank you for allowing mommy time to do my work when I needed and being good girls for daddy. I hope this is an encouragement to you girls one day.

I would like to thank my committee chair, Dr. Nathan Putney, for his constant support throughout this process. Dr. Putney, you have made yourself fully available to answer questions, given great feedback, provided encouragement, and challenged me to make changes to ensure this was the very best it could be. I am so thankful for you!
To my other committee members, Dr. Elizabeth Hillman and Dr. Xianqoin Yang, I can’t thank you enough for your expertise, support, and feedback throughout this process. Dr. Yang, thank you especially for being my sounding board and allowing me to continually talk things out before I even began this process. You have been a great friend to me!
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List of Abbreviations

Attitudes toward Mathematics Inventory (ATMI)
Curriculum-based measurement (CBM)
Common Core State Standards (CCSS)
Commercial off the shelf (COTS)
Computer technology (CT)
Differential Aptitude Test (DAT)
Digits correct per minute (DC/M)
Digits correct per two minutes (DC2M)
Digital game-based learning (DGBL)
Georgia Criterion-Referenced Competency Test (GCRCT)
Institutional review board (IRB)
Math anxiety rating scale (MARS)
Math anxiety rating scale revised (MARS-r)
Math anxiety scale for children (MASC)
National Assessment of Educational Progress (NAEP)
National Council for Teachers of Mathematics (NCTM)
Socioeconomic Status (SES)
CHAPTER ONE: INTRODUCTION

Introduction

Many populations of people struggle with the problem of math anxiety (Ramirez, Gunderson, Levin, & Beilock, 2013). Mathematics anxiety is becoming more prevalent, and more widely recognized as a reason that people are not able to effectively use mathematics in their everyday lives (Ramirez et al., 2013). For some, math anxiety begins in early elementary school, and influences feelings about mathematics into adulthood (Ramirez et al., 2013). Math anxiety is defined as “the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem” (Erden & Akgul, 2010, p. 4). Therefore, it is important that students are given optimal learning experiences during their formative elementary years to promote their future educational success (Geist, 2010). In order to create these optimal learning experiences for students, it is necessary that the factors that influence mathematics anxiety are understood. This study examines how predictor variables relate to the criterion variable of mathematics anxiety in order to understand the factors that are related to students’ math anxiety. Chapter one includes the background of the problem, the problem and purpose statements, the significance of the study, research questions, and research and null hypotheses. This chapter concludes by identifying important variables, definitions, and limitations to the study.

Background

Mathematics is a major component of successful functioning within the global economy (Geist, 2010). Unfortunately, the United States does not have a positive record of accomplishment when it comes to successful mathematics instruction. Research shows that over 20% of students in the elementary school setting are in need of remedial mathematics, which
refers to academic support that is in addition to what is provided in a regular classroom (Burns, Codding, Boice, & Lukito, 2010). With forty-five states adopting the Common Core State Standards (CCSS), the focus of mathematics instruction has moved from procedural instruction, to a discovery-based learning environment that allows students to construct their own knowledge (CCSS Initiative, 2012). Researchers, that are studying the progressive movement in mathematics, have determined that directly imparting mathematical knowledge to students is ineffective. Instead, students should be given the opportunity to discover rules, patterns, and mathematical concepts on their own (Alsup, 2004). This can be a time consuming way to deliver mathematics instruction and will leave some students without the prerequisite skills, such as fact fluency, to continue on to more advanced mathematics. Students in an inquiry-based environment may begin to feel unconfident and will need to learn to manage these feelings so they do not impact their success (Vukovic, Kieffer, Bailey, & Harari, 2013).

When students experience failure in mathematics at a young age, it may affect their abilities going forward. In the theory of psychosocial development, Erik Erikson described eight important stages of development. The fourth stage in Erikson’s theory of psychosocial development is referred to as Industry v. Inferiority (Erikson, 1950). During the later elementary school years, students are dealing with a crisis that determines their confidence levels in new situations (Erikson, 1950). Erikson believed that this particular crisis is dealt with during the elementary school years, typically between the ages of 6 and 11. Feelings of success or failure, called industry or inferiority, lead to the students’ levels of confidence in approaching problems (Erikson, 1950). When children experience achievement of any sort, they are satisfied from the positive experience and are able to effectively work through this part of their development (Erikson, 1950). However, a student who is only experiencing failure, which may occur as a
result of mathematical struggles, will begin to have feelings of incompetence and inferiority (Erikson, 1950). These feelings of success or failure could relate to mathematical success, as students who struggle with mathematics early in their education may begin to feel incompetent or incapable of performing well due to a lack of prior success in mathematics (Jansen et al., 2013).

Likewise, Albert Bandura (1997) developed the social learning theory and later emphasized the idea of self-efficacy. Self-efficacy is defined as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 31). Beliefs in one’s ability to successfully complete a task may not align with their actual ability. Self-efficacy has the ability to influence academic, social, and recreational activities in which people choose to engage (Miller, 2011). High levels of self-efficacy are essential to the ability to successfully perform tasks and achieve goals. Children who have low self-efficacy will have a difficult time forming social relationships and may develop a low sense of self-worth (Bandura, 1997). This idea of low self-efficacy is similar to Erikson’s concept of inferiority. Both theories acknowledge the adolescent time period as very important in the formation of self-efficacy and industry. Self-efficacy that results from education, can impact how likely students may be to become high-stress individuals or depressed (Miller, 2011). Self-efficacy developed during the adolescent years can also impact the resilience students have in new situations or when facing adversity (Miller, 2011). Erikson (1950) notes that these periods of adversity are the points in which students develop feelings of inferiority or of industry, which Bandura (1997) calls self-efficacy.

Students who have not experienced success in mathematics may become unconfident and this may lead to feelings of anxiety when approaching math-related tasks. Feels
have been related and directly linked to the development of anxiousness (Hutt, 2007). Students have been found to unconsciously affect their own ability to learn mathematics by allowing their feelings of inferiority to illicit negative feelings, leading to anxiety (Hutt, 2007).

Mathematics anxiety is something that can be irrational and result from feelings of inferiority (Richardson & Suinn, 1972). It is defined as “the feeling of tension that hampers the use of numbers and solving mathematical operations in individuals’ daily life and in their academic ambi
ts” (Richardson & Suinn, 1972, p. 551). The negative relationship so many individuals were having with mathematics became a more prevalent topic of study with the development of a tool that could effectively measure mathematics anxiety (Ashcraft & Krause, 2007). The original scale, that initiated the further development of math anxiety rating tools, was the Math Anxiety Rating Scale (MARS), which was a 98-item Likert scale developed in 1972 (Richardson & Suinn, 1972). This scale assessed math anxiety by examining participants’ responses to how they felt about descriptions of situations in which mathematics anxiety might be stimulated (Suinn, Edie, Nicoletti, & Spinelli, 1972). The MARS has a test-retest reliability coefficient of .78 after two weeks, with a significance level of $p < .001$. This level of reliability is comparable to other scales that are used in the field (Suinn et al., 1972). The validity of the MARS was analyzed with the mathematics section of the Differential Aptitude Test (DAT). The correlations between the MARS and the DAT were -.35 ($p < .05$) and -.32 ($p < .05$) for the retest (Suinn et al., 1972). The negative correlation showed that students who were performing low on the DAT were the students who reported high levels of math anxiety, according to their responses to the MARS (Suinn et al., 1972).

Since the development of this original tool, abbreviated versions of the MARS have been used along with modification to the scale for differences such as language and age
appropriateness (Hopko, 2003). These abbreviated scales included the Sandman Anxiety Toward Mathematics Scale (ATMS), Fennema-Sherman Mathematics Anxiety Scale (MAS), Mathematics Anxiety Rating Scale-Revised (MARS-R), and the abbreviated Mathematics Anxiety Rating Scale (sMARS), which range in length from six to twenty-five items (Hopko, 2003).

There is a growing amount of research that indicates the possibility of math anxiety beginning in early childhood (Vukovic et al., 2013). Math anxiety affects the amount of mathematics that students can learn throughout their lives, due to their impeded self-confidence (Vukovic et al., 2013).

In order to combat mathematics anxiety, at its onset, it is necessary to understand the factors that may have led to the development of math anxiety. There are many different predictor variables that have been linked to math anxiety; however, there is conflicting research regarding many of these variables (Ahmed, Minnaert, Kuyper, & van der Werf, 2011; Beilock, Gunderson, Ramirez, & Levine, 2010; Jansen et al., 2013). Prior research on mathematics anxiety has already examined many variables that may be related to the occurrence of mathematics anxiety. The theoretical framework along with the variables that have already been established in the literature will guide which variables should be included in this study, as well as additional variables that could be studied in a primary school population. Research shows that gender influences mathematics anxiety because girls have typically reported higher levels of mathematics anxiety even when their prior achievement or ability do not indicate any struggle with mathematics (Devine, Fawcett, Szucs, & Dowker, 2012; Geist, 2010; Gunderson, Ramirez, Levine, & Beilock, 2012). Also, socioeconomic status and ethnicity have shown to have a relationship with level of math anxiety (Geist, 2010). Specifically, students with low
socioeconomic status or those from a minority group have reported higher levels of mathematics anxiety (Geist, 2010). Students with higher levels of working memory have also been shown to have a greater occurrence of math anxiety (Ashcraft & Krause, 2007; Jansen et al., 2013). This means that students that are using their working memory more often for fact retrieval, instead of having automaticity, may become anxious about the more difficult objective of a task involving multiplication (Ashcraft & Krause, 2007; Jansen et al., 2013).

Therefore, the reliance on working memory for fact retrieval in later elementary school is related to the introduction of multiplication facts. The introduction and expectation of multiplication fact fluency is newly introduced in third and fourth grade. Therefore, it is possible that students are beginning to suffer with math anxiety this early in their education. This is a critical point in a student’s education and is also the point at which the gender gap often begins to widen, math anxiety may occur, and demographic variables start to have a greater impact on mathematics achievement (McCallum & Schmitt, 2011). The theoretical framework guides the inclusion of multiplication fact fluency as a possible predictor for mathematics anxiety, as this is a crucial piece of mathematics success and confidence. The mastery of these facts is expected to take place during a time in which students are developing their feelings of self-efficacy as it relates to the crises or challenges they are facing in school. Understanding the possible significance of the relationship between multiplication fact fluency, grade level math problem solving ability, math confidence, and math anxiety while controlling for demographics and prior achievement will increase the body of literature regarding the factors related to math anxiety for students in the primary grades.

The information processing theory supports the idea that when minds are overloaded with one task, the subsequent solving of a more difficult task may be too overwhelming (Courage &
Cowan, 2009). This deficiency could possibly lead to anxiety (Erikson, 1950). The information processing theory specifically states that the brain works in a way that is similar to a computer (Miller, 1956; Miller, 2011). This model of human thought helps to test views on the way that students think, store, and retrieve information (Miller, 2011). The way that our mind stores and retrieves information is a major component of information processing along with mathematical problem solving. Research on information processing in children has led to the development of three phases or stages of memory (Courage & Cowan, 2009). These stages interact with one another and are defined as encoding, storage, and retrieval (Courage & Cowan, 2009). These stages are not interacting in such a way that they always unfold in a similar order or fashion. In fact, the three stages are flexible as new information is gathered and attached to old information that can be recoded and modified to include additional information (Courage & Cowan, 2009). “As the developing child advances in perception, attention, knowledge acquisition, reasoning, and problem solving, there are implications for the retrieval of old information and the storage of new information” (Courage & Cowan, 2009, p. 4).

Children growing up in an information-rich society, may need especially intentional development of strategies for memory, including the acquisition, storage, and retrieval of information (Courage & Cowan, 2009). Although the use of strategies for information processing may seem logical, research has shown that many students have deficiencies in their ability to produce, use, or see the benefit from the use of information retrieval strategies (Courage & Cowan, 2009).

When dealing with multiplication fact fluency, information processing may be an important factor. Working memory is also part of information processing as it refers to the short-term memory. Along with working memory is the idea of chunking, which is the way that
we break information up into meaningful bits in order to better recall the information (Miller, 1956; Miller, 2011). The amount of information that humans can process, and how quickly they can do so, is limited. Using a specific strategy to recall information is considered to be effortful and uses up some of the limited cognitive resources (Courage & Cowan, 2009). This spurs the discussion of a major part of development in which strategies for overcoming these deficiencies are acquired (Miller, 2011). “Research on memory, the most studied area of development in information processing, shows that much of memory development is caused by the acquisition of strategies, the growing store of domain-specific knowledge, increased metamemory, and a greater functional capacity” (Miller, 2011, p. 323). If working memory is overloaded with these chunks of information, perhaps as is needed with the reliance on strategy-based retrieval, there are limited cognitive resources left for problem solving. In fact, when children are using their limited cognitive resources to implement a strategy, they do not have enough mental capacity remaining to adequately accomplish additional, often more important, parts of the original task (Courage & Cowan, 2009).

When students have multiplication fact fluency, also called automaticity, they will refrain from overloading their working memory and will have ample cognitive resources left for application of mathematical skills. Therefore, it is possible that students with fact fluency may have lower levels of mathematics anxiety and greater math confidence. Prior mathematics achievement, along with problem solving ability, has also been connected to mathematics anxiety (Ashcraft & Krause, 2007; Furner & Duffy, 2002). If students are able to use their cognitive resources on application, instead of fact retrieval, it is possible that more learning will take place, and students will experience lower levels of mathematics anxiety (Ashcraft & Krause, 2007).
The consequences that result from math anxiety in adolescents can go into adulthood. Feelings of anxiety are happening in the classroom as well as in everyday life activities involving the use of mathematics (Gunderson et al., 2012). When students, and eventually adults, begin to grow anxious about mathematics they are at risk for becoming “mathophobes” (Geist, 2010, p. 29). Adults have noted that using mathematics makes them nervous and impacts their daily life decisions (Jones, Childers, & Jiang, 2012). These daily life decisions often revolve around purchases that require mathematical processes to figure out costs (Jones et al., 2012). This culture of fear is something that cannot be ignored, and does not give the United States a great deal of hope for competitiveness in the unknown world of a global economy (Geist, 2010). The continued increase in the connectedness of our world makes it very important that students are confident in their mathematical skills and are not inhibited by irrational feelings of anxiety (Rubinsten & Tannock, 2010).

The gap in the literature exists due to the majority of the literature dealing with upper elementary, high school, collegiate level, and adult mathematics anxiety. Most of the research has been conducted with students that are middle and high school ages, as well as adults, and the origination of anxiety may be in a population of children that has been significantly overlooked (Jameson, 2013). A lack of research in the primary grades makes this a population that is necessary to research. A large portion of the research with children is not current because it does not take into account the current educational environment that most students are experiencing with the adoption of the Common Core State Standards (CCSS Initiative, 2012). There have been no studies that directly relate multiplication fact fluency to mathematics anxiety. There has also been inconsistency with results of the studies of mathematics anxiety. Therefore, this study
seeks to add to the literature regarding predictor variables for mathematics anxiety in primary grade students.

**Problem Statement**

Mathematics is a skill that is essential for everyday participation in society (Erden & Akgul, 2010). However, many people report that mathematics anxiety is a personal struggle that influences their ability to achieve certain goals or function confidently with mathematics on a day-to-day basis (Akin & Kurbanoglu, 2011). Research indicates that those who are identified as suffering from math anxiety have stated that it inhibits their ability to perform consistently in their everyday lives, discourages them from engaging in mathematics, and impacts their potential professional opportunities (Akin & Kurbanoglu, 2011). There is also a great deal of literature that examines the relationships between gender (Devine et al., 2012), socioeconomic status (Geist, 2010), and ethnicity (Geist, 2010; Stuart, 2000) as it relates to mathematics anxiety. Unfortunately, the predictors of mathematics anxiety have yet to be fully understood. Research has identified elementary school as the possible starting point for mathematics anxiety (Ramirez et al., 2013). However, there is a relatively small amount of research that has dealt with mathematics anxiety in primary school children and the factors that are related to high levels of mathematics anxiety. Literature has focused primarily on adults and older children (Witt, 2012). Third and fourth grade students experiencing math anxiety may begin to suffer from developmental dyscalculia, due to poor numeracy at a point in which mathematics becomes difficult (Rubinsten & Tannock, 2010). Math anxiety may also cause students to be unable to retrieve multiplication facts from memory due to the anxiety associated with those particular mathematical terms and concepts (Rubinsten & Tannock, 2010). It is necessary for young children to become confident in their mathematical abilities in order to avoid any impairment.
math anxiety may cause in their future (Rubinsteen & Tannock, 2010) and to be able to put interventions into place to assist with this problem (Ramirez et al., 2013). Therefore, this study seeks to fill the gap in the literature with regards to elementary school students’ math anxiety as it relates with multiplication fact fluency and grade level problem solving.

**Purpose Statement**

The purpose of this predictive correlation study was to test the theories of psychosocial development and information processing that relate multiplication fact fluency, problem solving, and math confidence to mathematics anxiety of fourth grade students at two suburban elementary schools in Northwest Georgia, while controlling for demographics and prior achievement. The criterion variable, mathematics anxiety, was generally defined as the students’ level of mathematics anxiety resulting from a four point Likert scale. The choices on the scale asked students to rate their level of anxiety when faced with math-related scenarios. The rating choices were: 1) not nervous, 2) a little nervous, 3) very nervous, and 4) extremely nervous. The predictor variables, multiplication fact fluency and problem solving ability, were generally defined as scores on separate grade-level fluency probes. The problem solving ability was scored according to a school-wide universal screening that is conducted quarterly, called the Easy Curriculum-based Measure (CBM). The fact fluency was scored using AIMSweb fact fluency probe. The math confidence level of students was defined as their score on a Likert-type self-response survey. This survey was a five-point scale with fifteen statements that were ranked from strongly agree to strongly disagree. The scale was a math confidence subscale of the abbreviated version of the Attitudes toward Mathematics Inventory (ATMI). The demographic variables of gender, socioeconomic status, and ethnicity were retrieved from archived data and were entered into the model first to serve as control variables. Gender was defined as male or
female, socioeconomic status will be determined by the student’s free or reduced lunch status, and ethnicity was identified as Caucasian, Hispanic, African-American, Asian, or Other as indicated on the student’s school enrollment form. The prior achievement control variable was defined by students’ scores on the Georgia Criterion-Referenced Competency Test (GCRCT) and their math grade average.

The significance of the relationships between multiplication fact fluency, problem solving ability, math confidence, and math anxiety were used to test the theories of psychosocial development and information processing. The general hypothesis of the study was that students with lower levels of multiplication fact fluency would have higher levels of mathematics anxiety. The variable of multiplication fact fluency, as it relates to the way the brain stores and retrieves information, tested the theory of information processing. When applying these theories to the research subjects, it was expected that the predictor variables of multiplication fact fluency, problem solving, and math confidence would have a statistically significant predictive relationship with the criterion variable, mathematics anxiety, while controlling for demographics and prior achievement.

The theories used for this study are Erik Erikson’s psychosocial development in connection with Bandura’s more current studies of self-efficacy in the social learning theory. Psychosocial development theory was developed to study the different crises people face throughout their human development. The most important stage, as it relates to this study, is the time frame that students are in elementary school, in which they develop either feelings of industry or inferiority based on their successful interactions primarily in school. This aligns with Bandura’s social learning theory as it relates to students’ development of self-efficacy or confidence in their ability to successfully interact within different context. Feelings of self-
efficacy in mathematics may be increased or diminished during these early interactions with the subject. The third theory applied to this study is the information processing theory that informs the way our brain stores and retrieves information. Students that are utilizing their working memory on fact retrieval, instead of more difficult content, may develop feelings of inferiority that lead to low self-efficacy or even mathematics anxiety.

As applied to my study, the theories of psychosocial development, information processing, and social learning, indicate that students in the elementary school years of development are faced with a crisis in which their self-efficacy is directly impacted by their ability to perform successfully in school. It is expected that the predictor variable of multiplication fact fluency will have a statistically significant relationship with the criterion variables of mathematics anxiety, because students with fact fluency will not be relying so heavily on their working memory for fact retrieval. Theoretically, this will allow them to use their working memory for problem solving and higher level thinking in mathematics. Those with more opportunities to go deeper into the content may experience higher levels of confidence in the subject area, and lower levels of anxiety.

**Significance of the Study**

This study holds a great deal of significance for educators. It is well documented that mathematics achievement is not at the level that it should be in the United States. Also, math ability is a strong predictor of future earnings and helps develop critical thinking and discipline when applying rules to unfamiliar problems (Ripley, 2013). These skills are very important to students as they enter the global economy (Ripley, 2013). Anything that is getting in the way of mathematics achievement, excluding basic cognitive ability, needs to be acknowledged and understood in order to intervene appropriately. Math anxiety has shown to be one of these
detrimental factors. The fact that females are showing greater levels of math anxiety in some studies makes it hold even greater significance (Devine et al., 2012). Teachers may be exhibiting gender bias that is encouraging or discouraging females in mathematics (Gunderson et al., 2012). This could have an impact on the course selections made by females, their college majors, and ultimately, their career choices (Ashcraft & Krause, 2007).

Additionally, if students are found to show mathematics anxiety at a young age it is important to have interventions in place, such as mathematics anxiety counseling, to assist students with this problem. Working memory is also shown to have a relationship with anxiety and fact fluency (Ashcraft & Krause, 2007). If teachers are aware of the cognitive resources necessary to complete strategy-based fact retrieval (Ashcraft & Krause, 2007), they may introduce these strategies for conceptual knowledge, then focus on the necessity of automaticity. Finally, the study of mathematics anxiety in young children is one that has been somewhat neglected (Ramirez et al., 2013). If it is consistently found that students are experiencing mathematics anxiety, regardless of cognitive ability, this may lead to a change in early numeracy development at the preschool age. Early literacy is given a great deal of attention, but the weakness of mathematics may lead to the development of more effective early numeracy programming.

Identifying the existence of mathematics anxiety as it relates to multiplication fact fluency in primary grade students, could possibly change the way in which students are taught this particular skill. Erikson’s psychosocial development describes the way students’ feelings of incompetence can debilitate their future performance (Erikson, 1950). Determining additional factors that may lead to mathematics anxiety could encourage teachers to use a more blended model of instruction, instead of focusing solely on discovery-based learning or direct instruction.
If the results of the study show that the relationship is empirically significant, the acknowledgement of mathematics anxiety could have a greater influence on the development of curriculum and instructional strategies.

**Research Questions**

The research questions for this study are:

- **RQ1**: Is there a statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence and math anxiety in fourth grade students while controlling for prior achievement and demographics?

- **RQ1a**: Is there a statistically significant contribution of the demographics variables in predicting math anxiety?

- **RQ1b**: Is there a statistically significant contribution of prior achievement in mathematics in predicting math anxiety?

- **RQ1c**: Is there a statistically significant contribution of multiplication fact fluency in predicting math anxiety?

- **RQ1d**: Is there a statistically significant contribution of math problem solving ability in predicting mathematics anxiety?

- **RQ1e**: Is there a statistically significant contribution of math confidence in predicting mathematics anxiety?

**Hypotheses**

The following are the research hypotheses for this study:

- **H1**: There is a statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.
**H1a:** There is a statistically significant contribution of demographic variables in predicting math anxiety.

**H1b:** There is a statistically significant contribution of prior math achievement in predicting math anxiety.

**H1c:** There is a statistically significant contribution of multiplication fact fluency in predicting math anxiety.

**H1d:** There is a statistically significant contribution of problem solving ability in predicting math anxiety.

**H1e:** There is a statistically significant contribution of math confidence in predicting math anxiety.

**Null Hypotheses**

The following are the null hypotheses for this study:

**H01:** There is no statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.

**H01a:** There is no statistically significant contribution of demographic variables in predicting math anxiety.

**H01b:** There is no statistically significant contribution of prior mathematics achievement in predicting math anxiety.

**H01c:** There is no statistically significant contribution of multiplication fact fluency in predicting math anxiety.

**H01d:** There is no statistically significant contribution of problem solving ability in predicting math anxiety.
**H01c:** There is no statistically significant contribution of math confidence in predicting math anxiety.

**Identification of Variables**

The decisions about what criterion and predictor variables to examine, as well as the measurement tools to utilize can be answered in many ways (Tabachnick & Fidell, 2007). Variable selections can be “provided by theory, astute observation, good hunches, or sometimes by careful examination of the distribution of residuals” (Tabachnick & Fidell, 2007, p. 122). Math anxiety (MA) is the criterion variable in this predictive correlation study. Mathematics anxiety is operationally defined as the extent to which students experience “the feeling of tension that hampers the use of numbers and solving mathematical operations in individuals’ daily life and in their academic ambits” (Richardson & Suinn, 1972, p.551). Math anxiety is measured by students’ score on the math anxiety scale for children (MASC). This score is a number in the range of 22-88. Higher scores will indicate higher levels of mathematics anxiety, while lower numbers indicate less anxious students. Multiplication fact fluency is a predictor variable that is defined by digits correct per minute (DCM) as measured by a multiplication fact fluency probe (Miller, Skinner, Gibby, Galyon, & Meadows-Allen, 2011). These scores are indicated by a number zero through 100. Higher numbers indicate students are more fluent with their multiplication facts, while lower scores indicate less fluency with regards to fact retrieval. Problem-solving ability is a predictor variable that is operationally defined as students’ scores on Mathematics Curriculum-Based Measure (CBM). Curriculum-based measures have been developed to show students’ problem solving abilities and mastery of grade level content (Keller-Margulis, Shapiro, & Hintze, 2008). The scores for the Easy CBM range from 0-50. The score of zero indicates low problem solving ability, while a higher score indicates higher levels
of grade level problem solving ability. Math confidence levels are indicated by the math confidence subscale of the ATMI (Lim & Chapman, 2013). These scores will range from 15-75, with higher scores indicating higher levels of math confidence and lower scores indicating low levels of math confidence.

Additional control variables for this study are related to the demographics of the primary age students being studied, along with their prior mathematics achievement. The first demographic variable is gender, which can be operationally defined as male or female. This is dummy coded and entered into the data analysis as a 0 = male and 1= female. Socioeconomic status (SES) is another control variable for this study. SES is defined by the free or reduced lunch status of each participant. Any student that is receiving free or reduced lunch is defined as low socioeconomic status. Any student that is not receiving free or reduced lunch is defined as not having low socioeconomic status. This variable will also be dummy coded with 0 = low SES and 1= not low SES. The final demographic control variable for this study is race. This variable will be defined as Caucasian, African-American, multi-racial, Hispanic, or Asian as indicated by the student enrollment sheet. This variable will include dummy codes where 0= Caucasian, 1= African-American, 2= multi-racial, 3= Hispanic, 4= Asian, 5= other or not indicated.

Students’ prior achievement includes criterion-referenced competency test scores and math average for the entire year. Student Georgia Criterion-Referenced Competency Test (GCRCT) scores are gathered by administration from school-wide test results reports. These math scores range from 750-990 and are indicated as such. Student yearly math averages are obtained from administration or secretarial staff from the school’s online gradebook system. The yearly math averages are a percentage that is entered as a number ranging from 0-100. Higher averages indicate higher levels of success, while lower grade averages indicate less prior
achievement. Table 1.1 shows a list of the variables that are described above, along with corresponding studies that were used to inform the decision to use these particular variables for the study of math anxiety in elementary school children. The demographics and prior achievement were entered into the model first because they are thought to be causally prior to the other predictors. The next addition is multiplication fact fluency, followed by problem solving, then math confidence. Multiplication fluency is thought to occur prior to the development of problem solving ability or math confidence. These decisions are described in further detail at a later time.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Studies Used to Inform Variables and Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Achievement</td>
<td>Ashcraft &amp; Krause, 2007; Erden &amp; Akgul, 2010; Furner &amp; Berman, 2003; Jansen et al., 2013; Ma &amp; Xu, 2004; Mahigir &amp; Karimi, 2012; Ramirez, Gunderson, Levin, &amp; Beilock, 2013; Rubinsten &amp; Tannock, 2010</td>
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<tr>
<td>Race</td>
<td>Mahigir &amp; Karimi, 2012; Moller, Mickelson, Stearns, Banerfee, &amp; Cecilia, 2013</td>
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<tr>
<td>Gender</td>
<td>Beilock, Gunderson, Ramirez, &amp; Levine, 2010; Devine, Fawcett, Szucs, &amp; Dowker, 2012; Frenzel &amp; Goetz, 2007; Geist, 2010; Geist &amp; King, 2008; Gunderson, Ramirez, Levine, &amp; Beilock, 2012; Maloney, Waechter, Risko, &amp; Fugelsang, 2012</td>
</tr>
<tr>
<td>Socioeconomic Status</td>
<td>Geist, 2010; Mahigir &amp; Karimi, 2012; Moller, Mickelson, Stearns Banerfee, &amp; Cecilia, 2013</td>
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</table>
**Research Summary**

In order to determine the relationship between math anxiety, multiplication fact fluency, math confidence, and math problem solving, a predictive correlation study will be conducted. Predictive correlation is used to examine relationships between variables, not indicate a causal relationship (Warner, 2013). This quantitative study will report the degree to which the variables contribute to the predicted value of the criterion variable. The study will be conducted by surveying students regarding their mathematics anxiety, using the Math Anxiety Scale for Children (MASC) and their math confidence indicated by the confidence subscale of the revised ATMI. Students will also be asked to take a multiplication fact fluency probe and mathematics curriculum-based measure (CBM) probe for problem solving. The quantitative values will be analyzed using hierarchical regression analysis in order to determine the significance of the relationship between the predictor variables and the criterion variable. Based on the literature review, there is no definitive answer to what causes math anxiety in elementary school students (Birgin, Baloglu, Catlioglu, & Gurbuz, 2010). However, there is significant research that examines the relationship between fact fluency and success in more difficult mathematics. As fact fluency is a great struggle for many students, it is important to examine the relationship this variable has with the existence of mathematics anxiety. There is no study specifically relating multiplication fact fluency and problem solving to mathematics anxiety in fourth grade students. Therefore, applying the hierarchical regression analysis to these variables may give greater insight into math anxiety at the elementary school level.
Assumptions and Limitations

Assumptions

It will be assumed that all students participating in the study will have the administration of the multiplication facts fluency probes, Easy CBM, math anxiety and math confidence rating scales under similar circumstances and with identical instructions. Another assumption of the study is that all known research-based predictor variables have been included in the study. If all variables have not been included the results may provide an unclear picture of the actual relationships of the included variables.

The external validity is the degree to which the results of the study can be generalized to another population in another setting (Warner, 2013). An assumption of the study is that the large population of third graders at this particular setting will be representative of third grade students in similar settings. This particular study will include students with varying achievement and demographic backgrounds, which may strengthen the external validity.

Limitations

Limitations to the study include generalizability, instruments, and causality. First, generalizability may be a limitation due to the sample being all from one school in one location. The MASC, the Likert scale used to determine students’ anxiety level, may be a limitation due to the fact that students will be doing a self-report. Likewise, the math confidence subscale is a self-report measure. Making sure that students understand that their answers are confidential and that there are no right and wrong answers is important to the study. Students must realize that if they are feeling mathematics related anxiety, it is okay to report that on the survey and not feel embarrassed about it. The confidentiality of the study must be ensured to the students. This may help them to honestly report how they feel, knowing that their answers will not be shared and
that they will not be penalized in any way. Causality is another limitation to the study. A predictive correlation study with a regression analysis is used simply to identify and examine relationships between predictor and criterion variables. At the conclusion of the study, the researcher will be unable to infer causality. For example, the conclusion will not be able to include that any of the variables actually caused mathematics anxiety (Warner, 2013). However, the study will hopefully lead to the understanding of how these variables relate, which may allow for interventions to prevent mathematics anxiety.

Threats to internal validity include omitted variable bias, errors-in-variable bias, sample selection bias, and simultaneous causality bias (Tabachnick & Fidell, 2007). When using multiple regression analysis it is important to make sure that all of the variables that are correlated to the criterion variable are included as a predictor variable in the analysis (Tabachnick & Fidell, 2007). If there is something that is left out of the analysis that has a significant relationship to the criterion variable, called omitted variable bias, the results of the study may not accurately represent what is intended (Tabachnick & Fidell, 2007). This threat will be controlled for by including all variables that have been determined to have a relationship to the criterion variable. Errors-in-variable bias is a threat to internal validity that is a result of the expectation that all variables are measured without any error (Tabachnick & Fidell, 2007). The task of measuring variables without any error is nearly impossible, which leads to the expectation that the inclusion of any variables will be those that have proven to be reliable (Tabachnick & Fidell, 2007). This threat to internal validity will be reduced by choosing valid and reliable instruments for all predictor variables. The Math Anxiety Scale for Children was analyzed for internal consistency with results of alpha levels ranging from $\alpha = .90$ to $\alpha = .93$, which indicates that the scale is valid and reliable (Chiu & Henry, 1990). The Easy Curriculum-
based Measure and Aimsweb Fact Fluency Probe have been deemed reliable and valid as well. These particular measures were examined with a group of third graders, which aligns with this study, and found to have validity and reliability.

Simultaneous causality bias is another threat to internal validity that that is a result of the criterion variable having impact on the predictor variables. This threat is controlled for by carefully selecting which variable will become the criterion variable and which variables will become the predictor variables. This decision should be made according to what research has already determined and what relationship the study will examine. Sample selection bias may be a limitation of the study due to the possibility of students not returning their assent and consent forms. There is a possibility that the students, who do not return their permission forms, may represent an important segment of the fourth grade population that is being studied. All fourth grade students will have the opportunity to participate in the study, but may choose not to do so.
Definitions

1. **Common Core State Standards**: A set of core standards that have been developed by representatives for the National Governor’s Association and adopted by forty-five states in order to have consistency and rigor for all students in the United States (CCSS Initiative, 2012).

2. **Constructivism**: A learning environment in which students are given opportunities to discover concepts, rules, and procedures themselves. Students go from concrete to abstract representations of learning (Bukova-Guzel, 2007).

3. **Curriculum-based Measure (CBM)**: A measurement used for progress monitoring and benchmark data that is based on the adopted curriculum standards (Keller-Margulis et al., 2008).

4. **Developmental Dyscalculia (DD)**: “a deficit in processing numerical information” (Rubinsten & Tannock, 2010, p. 2)

5. **Fact Fluency or Fact Automaticity**: “fast and accurate response” (McCallum & Schmitt, 2011, p. 276).

6. **Math Anxiety (MA)**: “the feeling of tension that hampers the use of numbers and solving mathematical operations in individuals’ daily life an in their academic amits” (Richardson & Suinn, 1972, p. 551).

7. **Math Attitudes**: “A liking or disliking of mathematics, a tendency to engage in or avoid mathematics activities, a belief that one is good or bad at mathematics and a belief that mathematics is either useful or useless” (Neale, 1969, p. 623).

8. **Math Wars**: A period of time in the 1990’s when the controversy and debate between traditional and reformed mathematics instruction started (Schoenfeld, 2004).
9. *Self-efficacy*: “Self-efficacy expectations are a person’s beliefs concerning his or her ability to successfully perform a given task or behavior and they are a major determinant of whether a person will attempt a given task” (Akin & Kurbanoglu, 2011, p. 265).

10. *Traditional Instruction*: A type of instruction in which a teacher delivers content through examples that students are to imitate. Students watch a teacher perform a set of procedures and then they practice these procedures for mastery (Schoenfeld, 2004).

CHAPTER TWO: LITERATURE REVIEW

Mathematics Anxiety in the United States

Mathematics anxiety is a problem that is facing many people across the country. A great deal of research has been done with regard to how math anxiety is impacting students in middle and high school, as well as adults. In order to be a productive member of society it is necessary that all people are able to perform basic and occasionally more in depth mathematical tasks. It is important to understand the factors that may influence mathematics anxiety and when this problem surfaces. Understanding the origin of this problem may lead to the ability for educators to intervene before students declare that they are unable to do math, and make life decisions based upon this feeling of incompetence. While much research has been done with regard to math anxiety, very little has been done to study this construct with students in early elementary school years.

Chapter two contains a review of the literature about the current state of mathematics in the United States and seeks to identify possible hindrances to mathematics achievement and growth. The literature review also examines the potential causes of math anxiety and how people of all ages are impacted by anxiety in math. The review of literature is intended to relate the presence of mathematics anxiety, and possible predictors, to the theoretical framework to demonstrate how they are connected in the current study. The theoretical and practical significance of the study are discussed.

Theoretical Framework

A great deal of change takes places for students during their elementary school years. For some, it is their first time away from home, their first time in any kind of formal schooling, and their first time interacting with a large number of chronological peers. The changes,
conflicts, and stages that occur during the formative school years for children are articulated by Erik Erikson’s theory of psychosocial development. This theory describes the way that students deal with a major change or crisis and how this impacts their development (Erikson, 1950).

**Psychosocial development.** In 1950, Erik Erikson developed the theory of psychosocial development that was articulated in his seminal work, *Childhood and Society*. His theory proposed that human development transpires throughout the entire life and is influenced by reactions to crisis or conflicts that occur in stages (Erikson, 1950). The way that an individual reacts to or deals with the conflict that is presented in each stage can have an either adverse or favorable impact on their ability to function effectively throughout their lives (Erikson, 1950).

The first stage of the theory describes the crisis that an infant experiences which focuses on the ability to develop trust (Erikson, 1950). This feeling of trust is established when the person taking care of them delivers consistent and reliable care that the infant can count on. According to Erikson (1950), when an infant does not experience these feelings of trust early on in life it can lead to feelings of mistrust and have a negative impact on the rest of their development.

The second stage of Erikson’s (1950) theory of psychosocial development is referred to as Autonomy v. Shame and Doubt. This stage occurs during early childhood or toddler years. The primary crisis in this stage is a child’s ability to gain control over different aspects of their life in order to have a feeling of autonomy and individuality (Erikson, 1950). Children experience success in this stage when they are able to do things such as feed themselves, dress themselves, and become toilet trained (Erikson, 1950). Young children experience a feeling of shame when they do not experience success in this stage of development.

The third stage in this theory occurs during the preschool years, and is the stage in which children are faced with the conflict of declaring power or control over situations in their lives
(Erikson, 1950). When students develop an appropriate amount of control over their lives, they will experience a feeling of purpose which will enable them to take initiative. Children who try to exert too much control over their environment will experience the disapproval of adults and this will lead negative reactions from adults, which in turn leads to feelings of guilt for the child.

The fourth stage of psychosocial development occurs during the elementary school years. This stage is called Industry versus Inferiority. Children in this stage are focused with the task of dealing with both social and educational demands in their environment (Erikson, 1950). When children have a feeling of success during this stage, they develop a feeling of industry or competence (Erikson, 1950). Those that are not able to feel competent, which may happen when social and academic skills are lacking, begin to feel inferior to those around them (Erikson, 1950).

The fifth stage of Erikson’s theory focuses on adolescence when children are faced with the conflict of relationships with others (Erikson, 1950). Adolescents struggle with developing their own identity and may become confused about who they are when they experience failure with relationships at this stage (Erikson, 1950).

The sixth stage of psychosocial development is the stage in which young adults deal primarily with romantic relationships. This stage addresses the issues with intimacy versus those of isolation (Erikson, 1950). It presents the conflict of finding a relationship that makes a young adult feel loved and capable of building successful relationships. The opposing feeling is the inability to have such a relationship, which may cause feelings of isolation and loneliness (Erikson, 1950).

The seventh stage of psychosocial development addresses the conflict called Generativity versus Stagnation (Erikson, 1950). This conflict is when middle-aged adults reconcile the idea
that they have, or have not, made a difference that will outlast them. This is accomplished through work success or the raising of children that will have long-lasting benefits (Erikson, 1950). Those in middle adulthood, that do not feel that they have had an impact on future generations, begin to have a feeling of surface involvement in the world and feel unimportant (Erikson, 1950).

The final stage of Erikson’s (1950) psychosocial theory addresses the conflict that arises at the end of life, called Ego Identity versus Despair. During this stage older adults reflect upon the choices and decision of their lives. This causes them to confront or reconcile feelings of fulfillment or regret (Erikson, 1950).

The stage of Erikson’s theory that is most related to the present study is the fourth stage, Industry versus Inferiority. When students are school-aged they are experiencing the conflict that has the potential to give a feeling of competence or inferiority (Erikson, 1950). When students are interacting with others in the school environment they begin to have a sense of pride in what they are able to accomplish. They may also begin to feel inferior when they are not performing exceptionally in academics and social relationships (Erikson, 1950). When students are celebrated for their mastery of skills and tasks, they develop a sense of industry or competence. Students who struggle in school, and are not rapidly mastering new skills, begin to feel inferior to their peers (Erikson, 1950).

Related to Erikson’s theory of psychosocial development, is Albert Bandura’s social learning theory. Bandura’s work on the social learning theory led to the idea of self-efficacy (Bandura, 1997). Feelings of self-efficacy, or the confidence in one’s ability to do something, can have an actual impact on performance and behavior (Bandura, 1997). Erikson’s idea that inferiority is determined by feelings of success can be related to Bandura’s concept of self-
efficacy which may occur due to feelings of inferiority that arise at the early elementary age. The self-efficacy that students develop, as a result of the conflicts they encounter, can impact their ability to persevere in adversity and avoid stress and depression (Miller, 2011).

The current study focuses on the large population of students that fail to learn multiplication facts at an early age. These students become convinced that they are unable to learn basic facts and become used to the familiarity of failing (Caron, 2007). Computation processes are such that there should be a level of learning, mastering, and automatic recall that enables students to use these facts in problem solving (Caron, 2007). “Developing automaticity frees up cognitive capacity for problem solving” (Caron, 2007, p. 278). If students become convinced that they are unable to recall basic facts, they will become unwilling to even attempt learning, and this could lead to math anxiety (Caron, 2007). These students have failed in this context for such a long period of time that they have in fact lowered their own expectations for themselves, and have resisted any attempt to learn. They have experienced a feeling of inferiority, as described by Erikson (1950), when faced with the crisis of mathematics education, specifically learning multiplication facts.

There is a population of identified special education students that are unable to retain basic facts to mastery, even after interventions have been put into place. Students with learning disabilities, in mathematics, may develop something called development dyscalculia (DD) (Rubinsten & Tannock, 2010). DD is a deficit in the ability to process numerical information (Rubinsten & Tannock, 2010). These students are out of the scope of this study, but there has been extensive research on these students and ways to impact their learning, when retention and utilization of facts requires more than incorporation of an appropriate strategy. These students are expected to show growth and high levels of achievement despite their disabilities. “Despite
these challenges, all teachers need to take the initiative to create a more effective learning environment for each and every student” (Glover, McLaughlin, Derby, & Gower, 2010, p. 460). A great amount of research has dealt specifically with the improvement of basic recall of multiplication facts with special education students (Becker, McLaughlin, Weber, & Gower, 2009). Most students that have an identified learning disability acquire the ability to use time consuming counting strategies instead of memorizing multiplication facts with automaticity (Becker et al., 2009). These strategies put students with learning disabilities at a major disadvantage, as their slow pace causes them to get even further behind in the math instruction (Becker et al., 2009).

Students with DD often have fewer available cognitive resources, which results in a higher demand on working memory (Bliss et al., 2010). Strategies such as Cover, Copy, Compare (CCC), have been successful in improving fact recall, but not to the point of total fluency (Becker et al., 2009). Additionally, the taped problems strategy and direct instruction flashcards have been used to improve fact fluency in this population (Glover et al., 2010). A study of students with moderate intellectual disabilities, sought to improve fact fluency by utilizing pegword mnemonics and a picture fading technique (Zisimopoulos, 2010). These rhyming word and picture associations helped students to achieve a greater level of recall with multiplication facts, but did not indicate mastery of skills (Zisimopoulos, 2010). Students with emotional behavior disorders (EBD) have also shown difficulty with attaining mathematics goals. This is due to the fact that their behavior can get in the way of their achievement and become an obstacle (Alter, Brown, & Pyle, 2011). Many of the recall strategies that special education students call upon for retrieval are actually interfering with the development of fact fluency (Zisimopoulos, 2010). It is extremely important for the special education population to
continue to grow in this area because “students with such skills are more likely to be independent and able to shop, make change, hold a job, and live independently” (Zisimopoulos, 2010, p. 126).

**Information processing.** The information processing theory presents the idea that the human mind works in a way that is very similar to a computer (Miller, 1956). The brain is able to store and retrieve information that has been acquired throughout life (Miller, 1956). George Miller offered the idea of chunking information into meaningful bits of information, and found that the brain recodes information in order to remember things that have been seen or heard (Miller, 1956). His ideas about chunking information included the idea that the human mind can effectively recall something that is between five and nine chunks long (Miller, 1956). Students are going to be using their working memory to complete tasks and will not be able to gain as much knowledge if they are using all of their cognitive resources on things that should be basic recall. According to Miller (1956), when students have the ability to chunk information into more meaningful parts, they will be more likely gain automatic recall and free up cognitive resources that allow for retention of a greater amount of information. Miller (1956) states that “the span of immediate memory imposes severe limitations on the amount of information that we are able to receive, process, and remember” (p. 95). Students who experience mathematics anxiety might be dealing with a heavy cognitive load due to the overuse of their working memory for basic recall. There is considerable research and evidence that considers working memory, as a part of information processing, plays an important role in mathematical cognition (Ashcraft & Krause, 2007). The understanding that math facts automaticity is essential to success in higher level mathematics is supported by the information-processing theory (Woodward, 2006).
Review of the Literature

Importance of Mathematics

Modern societies have developed in such a way that one of the primary and foundational skills that a person needs to effectively maintain their life is mathematics (Erden & Akgul, 2010). A large percentage of job or career choices require an applicant to be able to perform basic mathematical processes (Erden & Akgul, 2010). In fact, high school level proficiency in mathematics is a minimum requirement for approximately 90% of jobs today (Glover et al., 2010). “Government and professional groups have urged educators to help all students acquire mathematics preparedness for post-secondary education and employment” (Bottge, Rueda, Serlin, Hung, & Kwon, 2007, p. 31). It is the responsibility of educators to make sure that students are prepared to be competitive in the global economy and perform in a world that depends greatly on the ability to accurately and confidently use mathematics (Furner & Duffy, 2002).

Current state of mathematics. The current global economy, that students will be participating in, requires a great deal of knowledge about math and science, especially how it relates to technology. The future developments in technology will be based on the innovation that is a result of the students who are currently being educated (Birgin et al., 2010). Unfortunately, the United States has been in headlines, and in research reports, noting the ineffective teaching of math and science that is taking place (Ashcraft & Krause, 2007). In fact, the inferior rate at which students are mastering all levels of mathematical content can be quite disheartening (Ashcraft & Krause, 2007). Low levels of proficiency and large achievement gaps have been a consistently recorded result of the achievement scores for the United States (Glover et al., 2010). Students have been unable to successfully master standards and skills that will
enable them to participate in a workforce that is becoming primarily technological and requires a great deal of mathematics and science knowledge (Ashcraft & Krause, 2007). “The most dangerous, yet most persistent myth associated with mathematics education is that success in mathematics depends more on innate ability than on hard work” (Shores & Smith, 2010, p. 24).

**Achievement barriers.** There are many positions and views about what factors can explain the consistently poor performance of the students in the United States, when it comes to mathematics (Glover et al., 2010). When looking at mathematics anxiety, it is almost impossible to separate the discussion from mathematics achievement. Some studies have shown a correlation between mathematics achievement and mathematics anxiety, which lead to the question of what is causing students to struggle so greatly in the first place (Ma & Xu, 2004). There are many reasons why students may be performing at low levels in the United States. One possible barrier to achievement is the use of poorly designed textbooks and instructional materials (Glover et al., 2010). When students are learning with materials that are lacking the necessary steps for conceptual mathematical understanding, they will not be able to reach a high level of independence when utilizing the skills in a practical application (Glover et al., 2010).

Current research shows that approximately 20% of students at the elementary level are in need of academic support that is in addition to what the typical classroom teacher is delivering (Burns et al., 2010). Instructional delivery methods may be a reason for the lack of success in mathematics. Some teachers have been resistant to the shift toward reformed, discovery-based mathematics that focuses on conceptual understanding (Schoenfeld, 2004).

Early struggle in mathematics has been an indication of the likelihood that students will underachieve later in their mathematics education (Moller, Mickelson, Stearns, Banerfee, & Cecilia, 2013). Throughout the elementary school years, the gap in student achievement widens
and the number of students needing some sort of intervention shows continual growth (Moller et al., 2013). High-stakes testing may be one achievement barrier for these students (Moller et al., 2013). These tests have created a climate in which teachers feel torn between teaching the way they think is effective for long-term retention and the way that students will perform best on the end of the year test (Longo, 2010; Styron & Styron, 2012; Tanner, 2013;).

Inadequate funding for mathematics education and education in general, may be a substantial barrier in mathematics achievement (Mundia, 2012). The lack of adequate funding leaves a situation where effective teaching resources are lacking and professional development focusing on best practices may be non-existent (Mundia, 2012). Achievement levels are low, barriers to achievement are great, and mathematics reform has been deemed necessary to resolve this increasing problem.

**Core standards.** The lack of achievement in mathematics has led the United States to reform standards. The newly designed standards have been called the *Common Core State Standards* (CCSS). The CCSS were “designed to establish clear and consistent goals for learning that will prepare our nations’ students for success in college and work” (Flick & Kuchey, 2010). These standards were developed by the *National Governors Association* (NGA) and the *Council of Chief State School Officers* (CCSSO) in collaboration with teachers, content experts, administrators, parents, and state personnel (Flick & Kuchey, 2010). Governors and state school officers that participated in the CCSS development included representatives from 48 states, two territories, and the District of Columbia (Flick & Kuchey, 2010). Prior standards have been noted to have inconsistencies across the country and often represented a vast amount of content that had very limited depth (Flick & Kuchey, 2010). Those that developed the CCSS claim that “the standards stress not only procedural skill but also conceptual understanding, to
make sure students are learning and absorbing the critical information they need to succeed at higher levels” (Flick & Kuchey, 2010, p. 55).

There has been some criticism of these newly developed standards, including how they will impact the youngest students. Some believe that the CCSS were developed too quickly, have a hasty goal for implementation, and need some major revisions if they are to effectively meet the current needs for mathematics reform (Main, 2012). The NGA and the CCSSO claimed that the standards, as written, were aligned with other top performing countries. While this may be true, it is also noted that the CCSS are more rigorous than the current standards in 33 different states (Main, 2012). The adoption of these rigorous standards may be especially concerning for the youngest students who may be asked to master skills, at unprecedented rates, that seem above their developmentally appropriate level of learning (Main, 2012).

Another criticism of these new standards is the rapid development and implementation. The development of the standards included little input from those currently in the classroom, and was completed in approximately one year (Main, 2012). The rush to implement these standards has also left school districts with the ‘core’ standards, but lacking comprehensive assessments and resources for teachers (Main, 2012). Even more importantly, the lack of professional development that is needed to implement new standards, will likely lead to ineffective execution (Main, 2012). Another criticism of the CCSS is that there is not significant evidence that backs the need for nationwide curriculum. Likewise, the CCSS are simply a framework for learning and not a comprehensive curriculum (Main, 2012). This leaves many school personnel with a framework of standards but lacking curriculum, resources, and professional development (Main, 2012).
CCSS have not only drastically changed the standards nationwide, but have also required teachers to deliver instruction that looks much different than in the past. Standard algorithms, rules, patterns, and processes are not taught explicitly (Flick & Kuchey, 2010). Instead, teachers are to create learning environments that cultivate exploratory, constructive learning. Basically, students must discover the rules, patterns, and processes for themselves. This may be extremely difficult for teachers to facilitate with the lack of professional development along with the lack of comprehensive curriculum resources (Main, 2012).

The CCSS for mathematics include two separate sets of standards that are to be blended together to enhance students conceptual and procedural knowledge. These components include Standards for Mathematical Practice and Standards for Mathematical Content (Flick & Kuchey, 2010). The mathematical practice standards are the same eight standards across grade levels. The content standards include a balance of the procedural and conceptual knowledge students are expected to acquire (Flick & Kuchey, 2010). The idea of implementing mathematical practice standards alongside the content standards is that students will show a greater understanding and be less dependent on abstract procedures (Flick & Kuchey, 2010). Table 2.1 lists the eight standards for mathematical practice that are a part of the CCSS. Students will be unable to engage in the mathematical practices if they do not have a genuine understanding of the content standards (Flick & Kuchey, 2010). Likewise, students may not be able to understand the mathematical content or practices if the focus is solely on discovery-based learning and there is limited opportunity to develop math fact fluency. The inability to master fact fluency within the CCSS, along with the overwhelming amount of new standards, may lead students to experience a feeling toward mathematics that is similar to hearing a foreign language (Kotsopoulos, 2007).
Imaginably, these overwhelming feelings of frustration may lead to anxious feelings toward mathematics.

Table 2.1

*Common Core State Standards for Mathematical Practice*

| Standard 1 | Students will be able to make sense of problems and persevere in solving them. |
| Standard 2 | Students will be able to reason abstractly and quantitatively. |
| Standard 3 | Students will be able to construct viable arguments and critique the reasoning of others. |
| Standard 4 | Students will be able to model with mathematics. |
| Standard 5 | Students will be able to use appropriate tools strategically. |
| Standard 6 | Students will be able to attend to precision. |
| Standard 7 | Students will be able to look for and make use of structure. |
| Standard 8 | Students will be able to look for and express regularity in repeated reasoning. |

*Societal and Cultural Differences in Education*

A lot of the story about educational success in countries abroad revolves around the ability to demonstrate success in mathematics (Ripley, 2013). Interestingly, people in the United States seem to accept the possibility that people are just not capable in the area of mathematics, while this would not be acceptable in the area of reading (Ripley, 2013). This mentality has caused educational systems in the United States to ease their math instruction and expectations at early ages (Ripley, 2013). In fact, a study of third graders in Hong Kong and America showed that American students were already being given simpler tasks that required fewer higher level thinking skills (Ripley, 2013). Schools in the United States have also focused on the appearance of higher levels of academic opportunity, by creating environments that appear to be productive.
These appearances include the extensive inclusion of technology and school buildings that are beautifully landscaped to grab the attention of adults (Ripley, 2013). Many of the best, highest achieving, schools in the world are very high-tech, but their leaders do not feel inclined to brag about the use of these things. Instead, they have a very somber environment that is focused solely on learning (Ripley, 2013).

There are many differences in the way that the United States is educating children, when compared to other high achieving countries. Several Asian countries, along with Finland, have shown extremely high levels of academic success. The evaluation and analysis of these differences may serve as a model for the United States to follow, or at least consider.

**Finland as educational leaders.** In recent years, Finland has become a country that others around the world have sought to emulate (Sahlberg, 2013). Their success in education is partly because of a well-educated teaching force (Sahlberg, 2013). Only those in the top tier are even permitted to enter Finnish teachers’ colleges, and the training they receive is lengthy and rigorous (Ripley, 2013). Thousands of students graduating from high school each year compete for the few university primary school teaching degree positions. These require the completion of a five-year master’s degree (Sahlberg, 2013). In addition to the program itself, students applying for these few teacher degree program positions, are examined through a two-phase process (Malinen, Vaisanen, & Savolainen, 2012). The first part is the academic requirement that is familiar to most. However, there is a second part of the entrance exam that is used to evaluate the student’s personality and motivation traits and how suitable they are for the work of teaching (Malinen et al., 2012). At the completion of students’ five years of coursework, they are required to write a thesis that is comparable to the other fields of study at research universities in Finland (Sahlberg, 2013). The level of expertise that these teachers have, allows for higher
comfort levels with the material. This leads to fluency in critical thinking and high levels of numeracy (Ripley, 2013). Requiring teachers to have their first university degree, as well as a graduate degree in the same field, qualifies all primary school teachers as experts in their field and “enables them to gain more in-depth understanding of child development, pedagogical content, curriculum, assessment, school improvement, and leadership” (Sahlberg, 2013, p. 38).

The Finnish schools are also structured without the presence of external examinations, high stakes testing, and teacher accountability systems based on the demonstration of learning outcomes by the students (Sahlberg, 2013). This organization prevents top-down bureaucratic practices and allows teachers to practice pedagogy in a professional way (Sahlberg, 2013). While, this may seem troubling to policymakers in the United States, it leaves the teachers with the ability to put their extensive training into practice. “If education policies prevent teachers and students from doing what they think is necessary for good outcomes, even the best teachers will not be able to make significant improvements in these systems” (Sahlberg, 2013, p. 39).

Teaching in Finland is also focused on collaboration, autonomy, and professional responsibility (Sahlberg, 2013). Teachers in Finland were found to have the highest level of job satisfaction, due to their ability to express their pedagogical practices as desired and participate in horizontal leadership opportunities (Sahlberg, 2013). Teacher education programs in Finland are significantly different from other countries in how they a) require rigorous graduate degrees with five years of full-time study, b) focus their academic degrees on research, c) maintain equal status with other university departments, and d) utilize a clinical training school similar to how the medical field uses a hospital for training (Sahlberg, 2013).

The lesson from the Finnish schools is that teachers have a huge impact on student achievement, but educating better teachers may not always be the simple answer (Sahlberg,
Teachers and students alike must have the freedom to teach and learn in an environment that is empowering and where control lies within the local schools (Sahlberg, 2013). The Finnish schools have been able to develop internalized expectations for success, that are self-imposed, rather than those from an external source that is not familiar with the context of the school (Sahlberg, 2013).

**Asian language and culture.** Tests of mathematics achievement show that students in the United States compare grimly to their Asian counterparts (Bower, 1987). Over the past 50 years, Asian students have performed better than non-Asian peers, which leads to the realization that this gap is true and persistent and it exists prior to the attendance of formal school (Ng & Rao, 2010). Many explanations have been examined in order to explain the continued success of Chinese students. Among these explanations are 1) cultural beliefs, 2) parental practices, 3) educational systems and practices, 4) student motivation, and 5) the Chinese number-naming system (Ng & Rao, 2010).

The culturally shared beliefs that teachers hold, in the U.S. and in China, shed light on the teaching and learning differences in these countries (Correa, Perry, Sims, Miller, & Fang, 2008; Ng & Rao, 2010). The beliefs that teachers hold about what effective instruction and student learning look like, directly impact the decisions that are made in the classroom (Correa et al., 2008). It is possible that the beliefs that teachers hold can have a direct correlation with the achievement levels of students (Correa et al., 2008; Ng & Rao, 2010). Beliefs about teaching are acquired over time, as people participate in the educational system, and interact with the culture (Correa et al., 2008). In fact, cultural views of whether individualism, community, or collectivism is most important, can have an impact on the way each culture views teaching (Correa et al., 2008). Something may seem obvious in one country, but may not in another, due
to cultural norms. Studying the way other cultures view mathematics instruction enables teachers to question the way they traditionally teach, and encourages the construction of best educational practices (Correa et al., 2008).

“Comparisons of Chinese and U.S. student, teacher, and parent attitudes toward mathematics revealed significant differences in what it meant to be a successful student in mathematics” (Correa et al., 2008, p. 142). A study of Chinese teacher beliefs about mathematics, revealed that first-grade teachers in China feel that student interest in mathematics, real-life connections to mathematics, and student discovery of mathematical ideas are prerequisites to student achievement in mathematics (Correa et al., 2008). Chinese teachers of older students viewed prior knowledge, student interest, and student-teacher relationship as extremely important factors that influence levels of mathematics success (Correa et al., 2008).

First grade teachers in the United States were asked about their beliefs of mathematics instruction. They believed that discovery-based learning, paired with concrete representations with manipulatives, to aid conceptual understanding, were the most important to student success in mathematics. Teachers in the United States that teach older elementary students believe that practice and repetition, addressing student learning styles, and concrete representations through manipulatives, successfully facilitate student learning of mathematics (Correa et al., 2008).

Research has shown that teachers in China have greater content knowledge, when it comes to mathematics, and are more aware of how different mathematical concepts are connected (Correa et al., 2008). This may be why Chinese teachers focus so heavily on making real-life connections and tying them to the prior knowledge of students (Correa et al., 2008). Also, Chinese teachers are typically experts in one content area and may teach the same students, in one subject, for several years. On the contrary, teachers in the United States typically have
students for one year and teach them many different content areas. This may give Chinese teachers are greater opportunity to connect to the prior knowledge that they know students have and develop past mathematics concepts and ideas (Correa et al., 2008). The similarities in the way that Chinese teachers responded, as well as the similarities in the way U.S. teachers responded, serve as evidence that teaching is a cultural activity (Correa et al., 2008).

Socialization plays a part in the reason that Asian students show higher levels of mathematics performance. However, differences that are a result of language structures, and the mental representations of numbers, cannot be ignored (Bower, 1987). Language is something that is central to the expression and learning of mathematics (Han & Ginsburg, 2001). Language may also serve as a tool for cognition that can either assist or impede mathematical understanding (Han & Ginsburg, 2001). One of the greatest differences between children learning mathematics in the United States, and children learning in Asian countries, is the structure of the language itself. Early numeracy begins with the simple counting of objects. Both the English language and Asian languages have arbitrary names for the first ten numbers in the counting system (Han & Ginsburg, 2001; Ng & Rao, 2010). However, after the number 10, Asian languages do not introduce another number name until 100 (Ng & Rao, 2010). “The Chinese counting system can be thought of as a powerful cognitive tool: It perfectly embodies the basic ideas of the base-10 system” (Han & Ginsburg, 2001, p. 202). The counting system in the United States introduces seventeen new numbers before 100 (Han & Ginsburg, 2001; Ng & Rao, 2010). The counting of numbers past 10, in several Asian languages, is comparable to saying “ten-one, ten-two, ten-three, ten-four, ten-five, ten-six, ten-seven, ten-eight, ten-nine, two ten” (Han & Ginsburg, 2001). The strange practice in the United States is to reverse this pattern and say the units before the tens (Han & Ginsburg, 2001). When young students are asked to
represent numbers and work within the base-10 system it seems natural that children from Asian-speaking descent would have an easier time with these representations (Han & Ginsburg, 2001). “It is fair to say that English is simply not designed as well as Chinese for counting” (Han & Ginsburg, 2001, p. 202). Children that have learned to count and speak an Asian language, have a greater understanding of how numbers are structured (Ng & Rao, 2010). Asian-speaking children also have a strong foundation of the place value system that is crucial to the ability to cognitively represent numbers (Han & Ginsburg, 2001).

In addition to the language structure for counting, Asian languages have also developed mathematics terms in a way that are naturally descriptive of what they are trying to define (Han & Ginsburg, 2001). Chinese mathematical words are concrete and visual, practically defining themselves within their name (Ng & Rao, 2010). On the contrary, students in the United States have typically had a very great struggle with the memorization and comprehension of basic mathematical terms (Han & Ginsburg, 2001). This may be due to the fact that most mathematical terms get their names from other non-English words, like hexagon or quadrilateral, which are from Greek and Latin languages (Han & Ginsburg, 2001). Research of Chinese and English speakers revealed that Chinese speakers had a similar view of the clarity of mathematical terms (Han & Ginsburg, 2001). English speakers only believed that the terms were clear when it was a word they knew or could define, making the clarity of the word personal rather than universal (Han & Ginsburg, 2001). “Clearly, shared clarity is an advantage for the social activity of education, whereas personal clarity may not be” (Han & Ginsburg, 2001, p. 218). The consistent pattern of the language facilitates a greater understanding of basic number concepts (Ng & Rao, 2010). Therefore, it is thought that the clarity of the Chinese language, and other
similar Asian languages, may contribute to student success in mathematics (Han & Ginsburg, 2001).

**Student usage of time.** The difference in achievement levels of different societies or cultures has a lot to do with the importance that is placed on particular elements of society (Ripley, 2013). Mathematics education is highly valued in Asian cultures. Children from Asian homes are given a considerably greater amount of support in this area than children in the United States (Ng & Rao, 2010). For example, students in Korea have been compared to student athletes in the United States (Ripley, 2013). Korean parents push academics from a very early age, and often become obsessive about the academic success of their children. Likewise, parents in the United States have the same level of obsession with their children when it comes to athletics (Ripley, 2013). American parents often enroll their children in athletics as early as age three, while Korean parents begin rigorous academic training at this age. It is interesting that Korean parents and children have high levels of anxiety surrounding academics, while American parents and students have the same problem, but it lies with athletics (Ripley, 2013). Sporting events are such a major part of American society, especially schools, that the problem often becomes unconscious (Ripley, 2013). Considering the way that children spend their time may reveal a great deal about why there are such cultural and societal differences in the way students achieve (Fuligni & Stevenson, 1995).

Research has shown that Asian school students spend between one to two hours more at school than American children do (Fuligni & Stevenson, 1995). Asian students also spend more time pursuing after school activities that are related to academics (Fuligni & Stevenson, 1995). American students spent a large portion of their time with sports, social activities, leisure activities, and part-time jobs (Fuligni & Stevenson, 1995). The differences in the way the
cultures view academics drastically impacts the way students are spending their time outside of school. In the United States, there seems to be a confused message about the purpose of schools. “If school is about the yearbook club and lacrosse and the drama club, not to mention self-esteem, you’re not ever going to achieve excellence in academics” (Ripley, 2013, p. 1).

Mathematics Anxiety

Math anxiety exists among many people and is a great concern for teachers (Connor, 2008). It is often described as a feeling of tension or an unpleasant emotion that is brought on by math problem solving or anything that is dealing with the manipulation of numbers (Ahmed et al., 2011). It has also been described as “the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem” (Erden & Akgul, 2010, p. 4). This feeling of tension that is related to mathematics is not only within the context of formal mathematics, but also when individuals are using mathematics in their everyday lives (Akin & Kurbanoglu, 2011). For some reason, and at some point, a large portion of students become uneasy or unconfident about their ability to perform in situations involving mathematics (Zyl & Lohr, 1994). A large portion of mathematics anxiety research has focused on the predictors of anxiety and what results occur when someone experiences mathematics anxiety (Zyl & Lohr, 1994). There has been a great deal of research and documentation that has revealed math anxiety as one of the major causes of students’ avoidance of math courses, math careers, or any path that may lead to the need for mathematics usage (Ahmed et al., 2011). Students have reported that their feelings of panic when faced with mathematics, puts them into mental turmoil (Ravi & Manju, 2013). Some people believe that mathematics anxiety is developed over time, after low performance levels and a lack of success in the subject area (Mundia, 2012).
Math attitudes. Feelings of math anxiety may create a situation in which students believe that they are not capable of completing math tasks, prior to attempting the tasks, and may lead to a bad attitude about mathematics in general (Ravi & Manju, 2013). Past research has focused on mathematics anxiety as a similar construct to math attitudes (Akin & Kurbanoglu, 2011). Math attitude can be described as whether or not someone likes math, and whether they have a tendency to avoid math-related tasks or engage in mathematics (Akin & Kurbanoglu, 2011). Math attitudes also deal with someone’s feelings about whether or not they are good at math and whether mathematical skills are useful to them in any practical way (Akin & Kurbanoglu, 2011). Some of the students that are struggling with mathematics are facing this difficulty due to their feelings, emotions, and attitudes toward mathematics (Nunez-Pena, Suarez-Pellicioni, & Bono, 2013). Combating the growing number of students that are identifying themselves as having mathematics anxiety, may require a greater understanding of how emotional reactions, due to both environmental and personal issues, are impacting math performance (Nunez-Pena et al., 2013). Attitudes can impact the way students are able to learn.

It has been argued that the term ‘attitude’ is not sufficient in describing or explaining the physical and emotion feelings and tension that students experience when dealing with math anxiety (Akin & Kurbanoglu, 2011). There is also a difference in how students are motivated with regards to the way they view mathematics.

“Students who are internally motivated attribute their success to ability or effect and take personal responsibility for their performance. On the other hand, individuals who are externally motivated attribute their success to factors outside of their control, such as luck or task difficulty” (Shores & Smith, 2010, p. 24).
Math confidence. Another similar construct related to mathematics anxiety is the idea of math confidence. Students’ feelings about how well they may perform can have an impact on their level of achievement (Ahmed et al., 2011). Math confidence has been historically shown to have a predictive relationship with math anxiety (Ahmed et al., 2011). There is a pervasive view that the self-confidence, or self-concept, of a student may cause math anxiety (Ahmed et al., 2011). Students are often faced with feelings that they are not capable of performing in mathematics. The self-evaluation of ability may lead to students being unable to overcome anxious feelings when faced with mathematical tasks (Ahmed et al., 2011). An alternate view is that the math confidence of students is caused by the fact that they are faced with anxious feelings about math (Ahmed et al., 2011). Students that have feelings of math anxiety may be so emotionally stressed that it causes them to have an inaccurate evaluation of their actual abilities (Ahmed et al., 2011). A study by Ahmed et al. (2011), sought to evaluate the reciprocal relationship between math self-concept and anxiety. The results determined that there was a relationship between self-concept and test anxiety, but not necessarily mathematics anxiety (Ahmed et al., 2011). A person’s feelings of mathematics self-efficacy may play an important role in how they perform in mathematics, even more so than their actual mathematics ability (Haynes, Mullins, & Stein, 2004).

People Experiencing Math Anxiety

Adults experiencing math anxiety. Many adults are faced with mathematics anxiety that stems from early math experiences. Feelings of math anxiety and poor math attitudes can have tremendous effects into adulthood (Birgin et al., 2010). Math anxiety has been shown to impact the way many adults make daily decisions. For example, a study on the way people decide whether or not to make purchases considered the levels of math anxiety that arose from
being unconfident about figuring prices and understanding promotions (Jones et al., 2012). The study determined that those people with lower anxiety were more confident in the purchasing decision they made and adults with high levels of math anxiety were unconfident about their purchases (Jones et al., 2012). Adults often have a generally negative feeling or response to anything involving mathematics (Gresham, 2007). These feelings of negativity can be easily passed on to children and others through the actions and attitudes of adults (Erden & Akgul, 2010; Furner & Duffy, 2002; Ravi & Manju, 2013). Therefore, parents’ views of mathematics may play an important role in how their children view mathematics (Erden & Akgul, 2010; Furner & Duffy, 2002; Haynes et al., 2004). Some parents have very negative views and may portray these feelings to their children, including the notion that mathematical skills are actually useless (Haynes et al., 2004). Other children, who are experiencing a home environment that encourages mathematical skills and knowledge, and focuses on the importance of math skills, are likely to have greater success (Haynes et al., 2004).

**Teachers experiencing math anxiety.** Higher education students that wish to pursue a degree in elementary education are required to take very few mathematics courses (Beilock et al., 2010). Therefore, those who may tend to avoid mathematics in other aspects of their lives are still able to successfully pursue this type of degree (Beilock et al., 2010). There is an indication, based on research, that a teacher’s personal level of mathematics anxiety and attitude toward math can have a detrimental impact on a student’s feelings of math anxiety (Haynes et al., 2004). “If those people who are anxious about math are charged with teaching others mathematics- as is often the case for elementary school teachers- teachers’ anxieties could have consequences for their students’ math achievement” (Beilock et al., 2010, p. 1860). A research study by Erden and Akgul (2010) examined the relationship between perceived teacher social support and the
academic achievement of female students in mathematics. The results showed that there was a relationship between the way females felt supported by their female teachers and how girls were performing in mathematics (Erden and Akgul, 2010). It is also well-documented that pre-service education majors have the highest mathematics anxiety among all college majors (Beilock et al., 2010; Gresham, 2007). The idea that those who are going to responsible for teaching mathematics have a great deal of anxiety themselves, poses the question of whether or not teacher preparation programs are giving pre-service teachers the necessary preparation, experiences, and skills to effectively overcome their own anxiety (Gresham, 2007; Isiksal, Curran, Koc, & Askum, 2009). Again, these feelings of high math anxiety are likely to be passed on to students, from teachers, albeit unintentionally (Furner & Duffy, 2002; Gresham, 2007; Isiksal et al., 2009). Teachers are also being encouraged to teach with a more constructive model of instruction, but have been given preparation course work that includes only lecture and procedures (Alsup, 2004). Pre-service teachers are often seen as teacher-dependent and are lacking the autonomy that is necessary for creating a discovery-based or constructive learning environment (Alsup, 2004). Mathematics reform requires teachers to change from teaching in a traditional way, to a new and more exploratory type of learning environment for which these pre-service teachers have been given very limited support or training (Schoenfeld, 2004).

**Students experiencing math anxiety.** A large amount of research has documented that students from elementary age, all the way through post-graduate students, may experience mathematics anxiety (Zyl & Lohr, 1994). Students often make decisions about their ability to do something before an attempt has even been made. With mathematics, students from upper elementary through high school often struggle with mathematics achievement due to math anxiety (Kesici, Erdogan, & Kelesoglu, 2010). Student performance can be attributed to the way
they believe they will perform, the usefulness they feel toward the subject, and their own view of their ability (Kesici et al., 2010). Students may even experience what they consider to be a bad teacher in elementary school, and this may cause them to have negative feelings about mathematics throughout the remainder of their schooling (Kesici et al., 2010). Students have even reported that the way that teachers present material can come across as hostile or insensitive to student struggles, which may lead to higher levels of mathematics anxiety (Kesici et al., 2010). Students may have math anxiety simply because they have not experienced feelings of success in math (Ravi & Manju, 2013). This is supported by the psychosocial development theory that considers feelings of success, at different points in development, as crucial to feelings of pride and competence in one’s own ability (Erikson, 1950). Students in middle school may show their first signs of mathematics anxiety. A possible reason for this newly discovered anxiety at this stage is the introduction of equations and algebra (Erden & Akgul, 2010). When a student’s tension level is impacting their ability to learn content and perform in a subject, it is necessary for the teachers to find ways to alleviate the mathematics anxiety (Zyl & Lohr, 1994). Desensitization through muscle relaxation and imagining successful experiences can create a comfortable and calm learning environment that may alleviate some of the physical tension that comes along with mathematics anxiety in students (Zyl & Lohr, 1994).

Causes of Mathematics Anxiety

It is not completely clear what causes math anxiety (Devine et al., 2012). Early research in mathematics anxiety focused solely on the relationship it had with prior preparation or innate ability (Haynes et al., 2004). However, there are some things that have been shown to have a significant relationship with mathematics anxiety. These factors include variables that are environmental, intellectual, and those related to the personality of a student (Devine et al., 2012).
Environmental factors could include things such as classroom experiences, a particular characteristic of a teacher, and home environment (Devine et al., 2012). Intellectual variables include past mathematics experiences, problem solving ability, abstract thinking ability, and general cognitive abilities (Devine et al., 2012). Finally, personality can have an impact on mathematics anxiety. Personality traits that may have an impact on mathematics anxiety are self-confidence, learning style, attitude about math, general self-esteem, and feelings of self-efficacy (Devine et al., 2012).

**Gender.** Studies of math anxiety have shown gender to be one of the most critical variables (Ma & Xu, 2004). There is an acceptance among teachers, parents, and students that girls and mathematics are not a good combination (Frenzel & Geotz, 2007). A great deal of research has been done to examine the psychological, biological, and social explanations for a difference in mathematics performance between boys and girls (Frenzel & Geotz, 2007). Findings about gender and math anxiety have been studied extensively, but have not been consistent in their results (Devine et al., 2012). The most recent findings have shown that girls and boys are showing noticeably smaller differences when it comes to mathematics achievement and ability, which has led to a greater deal of research on the affective domains as they relate to gender differences in mathematics (Frenzel & Geotz, 2007). However, females are more likely than males to be debilitated by the conclusions that they have drawn about their ability to be successful with mathematical tasks (Shores & Smith, 2010).

In the early ages of education, there is no evidence that girls have higher levels of mathematics anxiety than boys; however, girls reveal greater levels of anxiety as they grow older (Erden & Akgul, 2010). Unfortunately, there may be a connection between the feelings that girls have about their own ability and the belief that has been largely accepted by society that girls are
not as strong when it comes to mathematical skills and abilities (Erden & Akgul, 2010). Results from a study by Devine et al. (2012), revealed a relationship between gender and mathematics anxiety. The findings showed that girls in the study have similar levels of mathematics achievement and performance ability, but for some reason reported higher levels of mathematics anxiety (Devine et al., 2012). This reveals a situation in which girls have the cognitive ability to perform at levels similar to boys, yet they are experiencing feelings of anxiety and fear when faced with mathematics tasks. While some studies show that females have a greater deal of math anxiety than their male counterparts, there are also other students that have found that there is not a statistically significant difference in math anxiety, based on gender (Akin & Kurbanoglu, 2011). The differences between males and females with regards to math achievement, math ability, and math anxiety have had mixed results (Haynes et al., 2004; Ma & Xu, 2004). If there is a connection or a relationship between gender and the occurrence of mathematics anxiety, it is necessary for solutions to be examined in order to make sure that girls are experiencing advanced math, keeping their career options open, and are able to productively participate in the global economy (Erden & Akgul, 2010). Women have had rising participation in the work force, but are not equally represented in areas of the work force involving mathematics, science, and engineering (Haynes et al., 2004).

**Socioeconomic status.** One factor that has been researched and considered to have an influence on mathematics anxiety is the socioeconomic status of the student (Furner & Duffy, 2002). Students that come from a background that includes a low socioeconomic status may have additional barriers to overcome that are not related to their actual cognitive abilities (Geist, 2010). Children that come from a low socioeconomic status are often seeing the example of parents that have a limited educational background, and may be portraying negative attitudes
toward mathematics to their own children (Furner & Duffy, 2002; Geist, 2010). These negative
apptitudes toward mathematics may cause students to worry about their ability and feel that they
will never be successful (Kesici et al., 2010). One disadvantage that exists for students that are
coming from a low socioeconomic status is having parents that may be less familiar with the
expectations of the educational system. The parents may also have lower educational and
occupational expectations (Riegle-Crumb & Grodsky, 2010). Students from a low socio-
economic status, that are struggling in mathematics, are less likely to have a parent that can assist
them with their work and are also less likely to seek outside assistance, like a tutor (Riegle-
Crumb & Grodsky, 2010). Socioeconomic status has shown to have a moderately positive
correlation with math achievement and a negative relationship with mathematics anxiety
(Cheema & Galluzzo, 2013). This indicates that the higher the socioeconomic status, the more
likely the student is to experience mathematics achievement and less likely that they will
experience mathematics anxiety (Cheema & Galluzzo, 2013). This may contribute to students’
feelings of anxiety and achievement in school when they come from a low socioeconomic status.

**Race and ethnicity.** Success in mathematics has been determined to have an impact on
some students’ level of mathematics anxiety. Students that are from minority groups face a
greater possibility of struggle in mathematics due to language barriers, parents’ educational
backgrounds, and prior achievement (Wei, Lenz, & Blackorby, 2013). Minority students have
been found to have significant mathematics deficits, while Hispanic students’ mathematics
deficits have been shown to grow over time (Wei et al., 2013). Feelings of anxiety with
mathematics may take a negative turn when minority students enter formal schooling (Geist,
2010). When students are forced to complete timed tasks and are not able to discover math in a
natural cognitive environment, they may start to have feelings of anxiety that are difficult to
overcome (Geist, 2010). The underrepresentation of minority students in higher level mathematics classes has been a topic of discussion and research for many years (Riegle-Crumb & Grodsky, 2010). A focus on this problem has led to a growing number of Hispanic and African-American students participating in upper level mathematics courses and taking advanced placement exams (Riegle-Crumb & Grodsky, 2010). Although the representational gap for minority students has been narrowed, the achievement level of these students is still far below their Caucasian peers (Riegle-Crumb & Grodsky, 2010). This leads to the investigation of whether the home situation or socioeconomic status of these students may impact their levels of achievement and whether there may be some sort of teaching disparity in the higher level courses (Riegle-Crumb & Grodsky, 2010). Students taking the higher level math courses, but not experiencing success, may become math anxious as a result. A study using race and ethnicity as predictors of achievement and math anxiety, for fifteen year old high school students, has indicated that African-American students have a greater achievement gap with their Caucasian peers than Hispanic students (Cheema & Galluzzo, 2013). Both Hispanic and African-Americans suffered from greater levels of mathematics anxiety than their Caucasian peers (Cheema & Galluzzo, 2013). While language barriers have impacted some students’ mathematics achievement, Asian students have not experienced the same struggle. This may be due to the way the Asian language is designed and how it relates to the base-10 system that is critical to mathematical understanding the United States (Ng & Rao, 2010). In fact, while minorities have been seemingly disadvantaged, students from Asian homes have actually experienced an advantage in the area of mathematics. This may be due to familiarity with a number system that utilizes consistent patterns that facilitate the understanding of basic number concepts (Ng & Rao, 2010). English language has a lack of correspondence between the way
numbers are named and their relative value in the base-10 system, which gives Asian students an advantage even over the English speaking peers (Ng & Rao, 2010). The cultural norms for Asian families, and the focus they place specifically on mathematics education, may also impact the way English-learning Asian students perform in schools in the United States (Ng & Rao, 2010).

**Prior mathematics achievement.** Math anxiety and math performance have received the greatest amount of research attention (Devine et al., 2012). Low mathematics performance has been shown to have a negative relationship with mathematics anxiety in studies that addressed primary and secondary students, as well as adults and university students (Akin & Kurbanoglu, 2011). It is possible that math achievement has been impacted, due to the exhaustion of the working memory on feelings of nervousness or anxiety, when completing math tasks (Jansen et al., 2013). Students that are highly anxious when it comes to mathematics will be especially frantic about assessments, which compound their feelings about the task (Devine et al., 2012). High math anxious students are more likely to experience success on assessments when they consider the format of the assessment to be informal or relaxed (Devine et al., 2012). Feelings of success in mathematics can also be supported by encouraging differentiation, through leveled instruction, that is appropriate for the learning abilities of each student (Jansen et al., 2013). Prior math achievement, or math performance, has been shown to have a negative correlation with students’ level of mathematics anxiety, which should encourage educators to focus on ways to make all students feel successful (Jansen et al., 2013).

A study of high school students sought to examine the relationships between math achievement, gender, race, socioeconomic status, math anxiety, and math self-efficacy (Cheema & Galluzzo, 2013). The results of the study indicated that math anxiety and math achievement
had a moderate negative correlation. This means that the students who showed higher levels of achievement had a lower level of mathematics anxiety. These students also showed higher levels of mathematics self-efficacy (Cheema & Galluzzo, 2013). Research is lacking in the area of how these variables affect younger students experiencing new, foundational mathematics skills.

**Physical Pain and Neurodevelopment Basis for Math Anxiety**

Much of the research on mathematics anxiety deals with the definition of mathematics anxiety as general fear or tension that is brought on by the mere thought of completing a mathematical task (Legg & Locker, 2009). However, there is more to math anxiety than simply feeling apprehensive or fearful when it comes to math (Lyons & Beilock, 2012). Research has shown that students who are experiencing high levels of math anxiety may actually be feeling pain when they are anticipating the completion of math-related activities (Lyons & Beilock, 2012). A study by Lyons and Beilock (2012) examined whether or not students that have high levels of math anxiety are actually experiencing a feeling of pain that is brought about by a neural pain response. The hypothesis was that simple anticipation of mathematics would actually cause a pain network to be activated in students that have high levels of math anxiety (Lyons & Beilock, 2012). Brain mapping of high math anxious individuals showed that there was an activation of neural regions, related to pain processing, when simply anticipating mathematical tasks (Lyons & Beilock, 2012).

Most of the pain and neurological studies involving mathematics anxiety have been reserved for adolescents and adults (Young, Wu, & Menon, 2012). A study focusing on the neural basis of mathematics anxiety in children showed that high math anxious children were actually activating a portion of their brain that indicated anxiousness (Young et al., 2012). This is important in regards to the time frame of early education because when students are acquiring
a great deal of mathematical skills, they may be hindered by the neurological basis of their mathematics anxiety. The finding suggested that the occurrence of math anxiety is actually brought on by specific situations and stimuli involving mathematics (Young et al., 2012).

Students often become uncomfortable with mathematics and the anxiety related to this subject may cause students to inhibit their ability to think clearly (Zyl & Lohr, 1994). Some research has been done in order to desensitize students who are experiencing anxiety related to mathematics and related activities. A study by Zyl and Lohr (1994) utilized certain relaxation techniques, while imagining anxiety-filled mathematical tasks, to combat these feelings. Some of the anxiety has been said to occur when emotion, related to mathematics, begins to block the pathways that knowledge, recall, and understanding must take (Zyl & Lohr, 1994). The point of desensitizing students was that the tension in muscles, related to mathematics, causes the body to actually send messages of failure to the mind (Zyl & Lohr, 1994). The hierarchy of situations that previously involved high anxiety, combined with relaxation techniques proved to be an effective measure for high school students that were anxious about mathematics. In fact, students that were exposed to relaxation techniques, intended to desensitize, showed significant reductions in their levels of mathematics anxiety (Zyl & Lohr, 1994).

Learning Environments

The learning environment, in which students are exposed to mathematics, can have an impact on the way students view the subject. Students that are learning in a constructive environment are experiencing a more exploratory approach to learning the concepts behind the mathematic procedures that are introduced in standard algorithms. Students that are experiencing math anxiety may have had poor math instruction (Ravi & Manju, 2013). Learning and testing environments may have a significant impact on the way students are learning
mathematics, the feelings they have about learning mathematics, and their levels of anxiety in relation to learning mathematics. A teacher must have a love of mathematics and portray the value of mathematics to students to encourage the appreciation of math (Ravi & Manju, 2013). Hands-on activities are an important part of the successful mathematics learning environment (Ravi & Manju, 2013). Students must learn the conceptual what and why behind mathematics before they learn the procedural ‘how’ of a standard algorithm (Ravi & Manju, 2013). A teacher’s goal in the classroom should be to give students a learning environment that gives students a chance to explore, discover, and respond to their learning (Ravi & Manju, 2013). Also, it is important for teachers to understand the successes and failures of their students and recognize what the students believe caused the outcome (Shores & Smith, 2010).

**Constructive versus traditional learning environments.** The way in which students understand and retain mathematical concepts is a great concern for all mathematics teachers at all levels of education (Chung, 2004). Since the 1990’s the way in which teachers instruct mathematical concepts has been a topic of great debate and even heated disagreement (Schoenfeld, 2004). This time of reform, in which traditional instructional methods were being challenged with reformed curricula that were more constructive, become known as the “Math Wars” (Schoenfeld, 2004). In a traditional learning environment, students would typically watch a teacher perform a set of procedures, like a standard computation algorithm, and then practice this algorithm until they mastered the process. According to the traditionalists, “the role of schooling should be to provide authoritative knowledge. Certain things are right or wrong; it is the responsibility of the teacher to say what is right and to make sure the students learn it” (Schoenfeld, 2004, p. 271). The problem with this instruction is that students are often learning how to follow procedures with limited understanding of when to use them and why the algorithm
is performed in the way it has been taught. Traditional instruction utilized primarily whole group instruction, while small group direct instruction may be a more effective way to teach students mathematical concepts (Glover et al., 2010).

Mathematics reform has called for a learning environment, in the primary grades, that encourages opportunities for students to make sense of mathematics and discover their own rules and properties through problem solving (Chung, 2004). “Teaching math word problem-solving through real contexts and situations puts the students in a position to learn the content by figuring out the mathematics and deepening their own conceptual knowledge” (Alter et al., 2011, p. 537). Conceptual understanding that comes along with a constructive learning environment has proven to be an effective way to teach mathematical skills and is suggested as a method for all grade levels and math content areas (Bukova-Guzel, 2007). One of the most common ways that teachers have implemented constructive learning is through the use of manipulatives. Unfortunately, many teachers believe that the use of manipulatives does not yield significant benefits for the students, especially when considering the amount of class time it takes to use these tools (Chung, 2004).

Ultimately, any educational controversy that results in one side taking complete control of the instructional direction becomes senseless (Schoenfeld, 2004). If students are in a learning environment that focuses only on the basics, they will be left without the knowledge of effective uses of mathematics in problem solving (Schoenfeld, 2004). On the other hand, “A focus on ‘process’ without attention to skills deprives students of the tools they need for fluid, competent performance” (Schoenfeld, 2004, p. 281). The war between the two main types of mathematics instruction has allowed educators and policy makers to lose sight of the possibility of compromise, which could result in a more complete education of students. There is a large
middle ground, which includes ideas about mathematics and instruction that are true for both sides of the argument (Schoenfeld, 2004). One commonly held belief that is relevant to this study is that students should be able to “add, subtract, multiply, and divide single-digit numbers automatically and accurately” (Schoenfeld, 2004, p. 282). This may require a constructive understanding in combination with a direct instruction, drill and skill recall intervention.

**Multiplication fact fluency.** Learning basic math facts is extremely important. The lack of knowledge and fluency in this area has been expressed as a major concern that impedes students’ ability to participate in higher level mathematics (Rao & Mallow, 2009). In fact, “basic math facts are the most fundamental computational skill for all higher math tasks” (McCallum & Schmitt, 2011, p. 276). Many students in today’s elementary school classrooms are struggling with mathematics (Becker et al., 2009). Two-thirds of students with learning disabilities have been shown to need remediation in mathematics (Becker et al., 2009). Despite the challenges that teachers face in the classroom, with differentiating instruction for different levels of learning, it is important for the teachers to take the necessary initiative to create the appropriate learning environment for the needs of every single student (Glover et al., 2010). Research has shown that most of these students are able to use time-consuming counting strategies for multiplication fact retrieval (Becker et al., 2009). However, this requires a large amount of time and often leads to struggling students falling further behind the instruction of the class (Becker et al., 2009). Students that are not fluent with their basic facts will be spending a lot of time on retrieval, and the effort required to complete math tasks will prevent them from choosing math-related tasks in the future (Bliss et al., 2010). “Students who can respond accurately and rapidly (automatic or fluent responding) to basic math are more likely to meet advanced math objectives and have less math anxiety” (Bliss et al., 2010, p. 156). Some students are spending so much of
their cognitive resources trying to retrieve basic facts, that they are unable to attempt more advanced or complex mathematics concepts (Bliss et al., 2010).

There are many different procedures that have been researched to determine the best way to increase students’ multiplication fact fluency. Among the strategies that have been effective are direct instruction with flashcards (Glover et al., 2010), a cover, copy, compare method (Becker et al., 2009; Parkhurst et al., 2010), the taped-problems method (Bliss et al., 2010; Miller et al., 2011; Parkhurst et al., 2010), simultaneous prompting procedures (Rao & Mallow, 2009), and the use of technology drill-based games (Jones, 2011; Parkhurst et al., 2010; Schaaf, 2012). None of these strategies focused on the conceptual understanding of the facts, only the fluency and automaticity with which students were able to recall basic facts. “Information –processing theory supports the view that automaticity in math facts is fundamental to success in many areas of higher mathematics” (Woodward, 2006, p. 269).

**Digital game-based learning.** As students continue to struggle with mathematics, specifically fact fluency, the use of digital gaming in education is becoming a very popular trend (Becker, 2007; Hong, Cheng, Hwang, Lee, & Change, 2009; Li & Ma, 2010). Research in the area of digital game-based learning (DGBL) has increased drastically in the past ten years (Blanco et al., 2012; Hwang & Wu, 2012; Van Eck, 2006). This may be explained by the large amounts of time that students spend playing video or computer games in their leisure time (Erhel & Jamet, 2013). The amount of time that children spend playing computer games makes it clear why the educational systems would try to harness that already existing motivation (Ronimus, Kujala, Tolvanen, & Lyytinen, 2014). The question has been raised about whether or not it was realistic to believe that students’ interest in video games could be translated into meaningful learning (Erhel & Jamet, 2013). This increase in DGBL research resulted in a large majority of
people believing that educational games could actually promote a positive learning experience, as well as motivation and engagement (Tsai, Yu, & Hsiao, 2012). In fact, the National Council of Teachers of Mathematics (NCTM) has emphasized the importance of incorporating computer technology (CT) in math instruction (Li & Ma, 2010). Gaming within the classroom is something that has been shown to increase motivation and interest with students (Blanco et al., 2012; Erhel & Jamet, 2013; Hwang & Wu, 2012). Unfortunately, the appeal that generates curiosity, motivation, and interest in games, may not have the desired long-term effects (Ronimus et al., 2014).

Playing games is a natural process that allows students to develop not only thinking skills, but all social skills that are required for games (Hwang & Wu, 2012). Even though people generally believe that digital games have a benefit, there is still some resistance to DGBL and its full incorporation into the educational system (Tsai et al., 2012). This is possibly because some research indicates that the games are not actually producing greater amounts of knowledge acquisition, but instead they are simply motivating and engaging students (Blanco et al., 2012; Tsai et al., 2012). A study by Erhel and Jamet (2013) examined the learning difference between students that were given feedback and instructions, in a more traditional learning experience, with those that were given similar instruction in the form of DGBL. The results of the study indicated that the DGBL provided high levels of motivation, but did not show greater levels of content knowledge or acquisition (Erhel & Jamet, 2013). This may be explained by the fact that “games are effective not because of what they are, but because of what they embody and what learners are doing as they play a game” (Van Eck, 2006, p. 18). Commercial off-the-shelf (COTS) games can be very beneficial if they are supported by an appropriate learning task, and are aligned with the appropriate content and curriculum. (Van Eck, 2006). One benefit of COTS
DGBL, is the ability for students to make a connection between the abstract concepts that they are learning and a real-life situation (Panoutsopoulos & Sampson, 2012).

Student motivation is a big part of DGBL. Students may experience intrinsic or extrinsic motivation that results in their desire to change a situation to reach a preferred outcome (Hong et al., 2009). Students that are intrinsically motivated will participate in gaming just for the sake of overcoming the challenge of a game (Hong et al., 2009; Ronimus et al., 2014). Extrinsically motivated students will view the DGBL as a means to the desired end (Hong et al., 2009). Games have a lot of advantageous features, such as user-centered design, interactive processes, and the newest technology (Hong et al., 2009). However, motivation for game playing and the high levels of engagement that players have, are the reason that DGBL is getting so much attention (Hong et al., 2009).

In order to argue for the benefits of knowledge acquisition, as a result of DGBL, it is necessary to understand what factors contribute to the effectiveness of games (Tsai et al., 2012). Research has shown that some students are unable to effectively learn during DGBL, because they are concentrating on scoring or winning the game (Tsai et al., 2012). The elements of the game become the purpose of the game, and students may become distracted by the goals or situations, neglecting the content (Tsai et al., 2012). The effectiveness of DGBL can only be as good as the game design. Games must be designed in a way that has content at the center of the design, with appropriate gaming elements (Hong et al., 2009). The evaluation of digital games has been done on the basis of the following: a) mental challenge, b) enhancement of content knowledge, c) emotional fulfilment, d) development of thinking skills, e) development of interpersonal skills, f) development of spatial ability, and g) improved body coordination (Hong et al., 2009).
The consensus, within most of the DGBL literature, was that games can enhance discovery, achievement, motivation, attitudes, and cognitive development for students (Hong et al., 2009). DGBL can also encourage the differentiation of learning, serving as an intervention or acceleration tool, depending on students’ needs (Hong et al., 2009). Another benefit of DGBL is the application and generalization of classroom skills to another situation or context (Hong et al., 2009).

Research has provided evidence that the use of DGBL, in the context of mathematics, results in at least equal, sometimes greater, effectiveness in achieving the learning objectives (Panoutsopoulos & Sampson, 2012). Also, the levels of motivation and interest in mathematics were shown to increase when DGBL was utilized (Panoutsopoulos & Sampson, 2012). “When developing digital learning games for young children with poor academic skills, it is important that the game fulfills the design principles that support long-term engagement and interest in the subject matter” (Ronimus et al., 2014, p. 245). According to the NCTM, the presence of CT does not imply that learning objectives will be met (Li & Ma, 2010). Rather, the blend of CT with pedagogical practices that align with the knowledge of the impact of CT on mathematics achievement (Li & Ma, 2010). Therefore, content must be a priority within the game.

The instructional game Timez Attack was used in a study of fact fluency, which specifically relates to the current study, to determine if DGBL would impact students’ basic fact fluency (Jones, 2011). The results of the study showed that students maintained high levels of interest and motivation, when using DGBL, and also had statistically significant gains in their fact fluency (Jones, 2011). Ultimately, “game-based learning can be a very efficient tool if it is designed to reflect pedagogical and learning needs in a real educational setting” (Hong et al., 2009, p. 431). The increased use of technology, including computers and mobile devices, makes
it imperative that digital learning is a part of the educational system, for content mastery as well as preparation for participation in the global economy (Schaaf, 2012). It is the responsibility of the educator to identify the tools that align with content objectives, and implement them with the appropriate level of instruction and feedback to make them successful.

**Literature Summary**

The literature shows that mathematics anxiety is a pervasive problem that needs to be addressed in order to produce productive members of society. Prior predictors of mathematics anxiety have shown to be gender, prior achievement, socioeconomic status, and race and ethnicity. People experiencing mathematics anxiety have been well-documented from later elementary years all the way through adulthood. The feelings of panic or helplessness, referred to as mathematics anxiety, are not always directly related to actual ability to perform mathematics tasks. People who are suffering from mathematics anxiety often avoid mathematics and limit their career opportunities because of a possibly irrational feeling of tension that comes along with even the thought of mathematics. Learning environments, testing environments and the way the teacher portrays the usefulness of mathematics, can have an impact on the level of student mathematics anxiety.

**Theoretical and Practical Value of Study**

The theoretical significance of this study is the idea that students are developing feelings of success or failure that may ultimately impact the rest of their development. This development is occurring in the formative primary elementary school grades. This period of development is critical to the way students may view mathematics for the rest of their lives. If students struggle early on, they may have a sense of inferiority that is not easily overcome, or they may develop
low mathematics self-efficacy. If students believe that they are simply not good at math, they may never be able to pursue personal goals because of an attitude or feeling about math.

The practical value of the study comes with the understanding that in order to fix a problem, there must be a clear picture of what is causing the problem. If the feelings towards mathematics can be developed at an early age, such as the primary grades, there should be a focus on the skills that are being taught at that age that might cause some students to have feelings of success, while other are feeling inferior. Experiencing quality learning is extremely important for students and requires a lot of time and effort on the part of both teachers and learners (Frenzel & Goetz, 2007). “Learners are more willing to invest such effort if learning activities are affectively rewarding— that is, enjoyable and interesting rather than anxiety-laden or boredom-inducing” (Frenzel & Goetz, 2007, p. 498).
CHAPTER THREE: METHODS

Introduction

The purpose of this study was to examine the predictive relationship of multiplication fact fluency, problem-solving ability, math confidence with mathematics anxiety, while controlling for demographics and prior achievement. Fourth grade students at two suburban elementary schools in Northwest Georgia completed a self-report survey to determine their levels of math anxiety and math confidence, along with a fact fluency probe and a problem solving assessment. In this chapter, the research method and design are discussed as well as how they related to the present study. The research questions, research hypotheses, and null hypotheses are also stated to represent the purpose of the study and also to guide the study. A description of the participants, settings, instrumentation, and procedures for the study are identified and described.

Design

This non-experimental, predictive correlation research study examined the relationship between predictor and criterion variables. A non-experimental research study is one that does not involve any manipulation of the variables, but rather is used to examine the relationships between variables that are thought to be significant (Warner, 2013). The purpose of the study is not to infer a causal relationship between predictor variables and the criterion variable, but instead to examine the ways in which predictor variables may be related to a criterion variable (Warner, 2013). In this study, the relationship between multiplication fact fluency, problem solving ability, math confidence, and math anxiety was studied while controlling for demographics and prior achievement. No variable manipulation or interventions were included in this study. Therefore, all experimental or quasi-experimental designs were ruled out (Gall,
The nature of the study, variable relationships, makes non-experimental predictive correlation the most appropriate research design for this study. Table 3.1 below shows the different quantitative research design options that are non-experimental and represents the decision making process that resulted in predictive correlation as the appropriate design for this study.

Table 3.1

<table>
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<th>Non-experimental Research Design Decision Making Process</th>
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<td><strong>Design</strong></td>
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Research Questions

The research questions for this study were:

**RQ1:** Is there a statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence and math anxiety in fourth grade students while controlling for demographics and prior achievement?

**RQ1a:** Is there a statistically significant contribution of the demographics variables in predicting math anxiety?

**RQ1b:** Is there a statistically significant contribution of prior achievement in mathematics in predicting math anxiety?

**RQ1c:** Is there a statistically significant contribution of multiplication fact fluency in predicting math anxiety?

**RQ1d:** Is there a statistically significant contribution of math problem solving ability in predicting mathematics anxiety?

**RQ1e:** Is there a statistically significant contribution of math confidence in predicting mathematics anxiety?

Hypotheses

The hypotheses for this study were:

**H1:** There is a statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.

**H1a:** There is a statistically significant contribution of demographic variables in predicting math anxiety.
**H1b:** There is a statistically significant contribution of prior math achievement in predicting math anxiety.

**H1c:** There is a statistically significant contribution of multiplication fact fluency in predicting math anxiety.

**H1d:** There is a statistically significant contribution of problem solving ability in predicting math anxiety.

**H1e:** There is a statistically significant contribution of math confidence in predicting math anxiety.

**Null Hypotheses**

The null hypotheses for this study were:

**H01:** There is no statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.

**H01a:** There is no statistically significant contribution of demographic variables in predicting math anxiety.

**H01b:** There is no statistically significant contribution of prior mathematics achievement in predicting math anxiety.

**H01c:** There is no statistically significant contribution of multiplication fact fluency in predicting math anxiety.

**H01d:** There is no statistically significant contribution of problem solving ability in predicting math anxiety.

**H01e:** There is no statistically significant contribution of math confidence in predicting math anxiety.
Participants

The participants in this study were fourth grade students at two elementary schools in the same county in Northwest Georgia. The target population was fourth grade students, and this sample was selected from two suburban schools, including all fourth graders, to represent a large sample population. In a predictive correlation study in which relationships between variables are reported, it is suggested that a minimum number of total participants be greater than 100 (Warner, 2013). Other research conventions, for hierarchical regression analysis, suggest that a multiple correlation sample size should be $N \geq 50 + 8m$ and when the individual predictor variables are tested the sample should be $N \geq 104 + m$ where $m$ is equal to the number of predictor variables (Tabachnick & Fidell, 2007). In all conventions, it is suggested that sample size considerations are made based upon the largest suggested sample size when there are different types of analysis being conducted. Therefore, the sample size for this study included all fourth grade students who returned consent and assent forms. After collection of assent and consent forms, the resulting sample was $N = 174$. The sample was a nonprobability sample (Rovai, Baker, & Ponton, 2013) because there was no randomization involved in the selection of the participants. The sample was also a convenience sample. This is most appropriate when there is a group of participants that are readily available, due to access or proximity, to the researcher (Warner, 2013).

Setting

The settings for this study were two large suburban elementary schools in Northwest Georgia. The exact enrollment, for grades Kindergarten through fifth grade, was estimated to be 1,200. The number of students that are receiving free or reduced lunches was gathered from the schools’ archived data. The archived data also included information about students’ prior
achievement in the classroom, or standardized tests, and any services received such as English
Speakers of Other Languages (ESOL), Early Intervention Program (EIP) services, or gifted
services. The data regarding student achievement levels on the grade level problem solving
measure, CBM, was gathered from the schools’ shared networks where the data is stored. The
settings for this study were selected due the access of the researcher.

The demographic data for the participants was collected using information found in the
Aspen Student Information System (SIS) that the schools utilize for student information. Aspen
SIS is an information system that is managed by Follett Software Company. The system is used
to track student information including grades, health information, schedule, enrollment
information, parent or emergency contacts, email distributions, instructional setting information,
and even curriculum resources for instructors (Follett, 2013).

The setting for the instrumentation was twelve different fourth grade classrooms that had
between 27 and 32 students in each. The twelve fourth grade classrooms were from two different
elementary schools. This gave a possible sample size between 324 and 360 student, depending
on the return of assent and consent forms. The researcher read a script to each of the classrooms
during the administration of the assessments and surveys. This ensured consistency in the way
the students experienced this portion of the data collection. The students were all surveyed the
same week, during their first period classes to ensure that the time of day did not impact student
performance or responses to the surveys.

The curriculum that the school is currently using aligns with the Common Core State
Standards. The CCSS encourage teachers to use discovery-based learning that allows students to
create their own patterns and rules for mathematics.
The fourth grade students that were studied are in the beginning phases of adopting the CCSS for mathematics. The new curriculum includes a shift in instructional delivery methods, from repeated practice to discovery-based or constructive learning activities. The purpose of these learning activities is to allow students to create their own knowledge of the concepts and to develop their own rules and patterns. The idea is that students will have higher levels of procedural and conceptual knowledge whenever they have discovered the rules and patterns for themselves, rather than being told what the patterns should look like and how to follow mathematical rules. The significance of a relationship between fact fluency and math anxiety, in a discovery-based setting, may lead to the incorporation of a more balanced approach to mathematics instruction.

Instrumentation

Criterion Variable

Math anxiety. Math anxiety was measured using a survey. The survey that was used in this study is the Mathematics Anxiety Scale for Children (MASC), to assess students’ level of mathematics anxiety (Chiu & Henry, 1990). This particular rating scale was developed by Chin and Henry, from a longer version of the Math Anxiety Rating Scale (MARS). The MASC is more appropriate for younger students with shorter attention spans and it had a high correlation ($r = .97$) with the longer version of the scale (Chiu & Henry, 1990). The rating scale consists of 22 statements that students are asked to rate, according to how the situations make them feel, on a four point scale including: 1) not nervous, 2) a little nervous, 3) very nervous, and 4) extremely nervous (Chiu & Henry, 1990). The rating scale is used to measure student math anxiety when performing mathematical tasks for a formal assessment, thinking about learning new mathematics content, problem solving in mathematics, and interacting with a math teacher (Chiu
The scale was developed due to the inappropriate nature of the existing mathematics anxiety rating scales for children (Chiu & Henry, 1990).

This rating scale was chosen because of the level of reliability. Internal consistency reliability coefficients for the rating scale were calculated for elementary and middle school students. Cronbach’s alpha levels ranged from $\alpha = .90$ to $\alpha = .93$, which indicates that the scale is reliable, according to education research conventions. Construct validity was calculated by correlating the MASC scores with semester grades. Identifying the level of anxiety for different constructs was done by performing a factor analysis. The specific anxiety factors assessed with this survey are 1) mathematics evaluation anxiety, 2) mathematics learning anxiety, 3) mathematics problem solving anxiety, and 4) mathematics teacher anxiety (Chiu & Henry, 1990). This survey will be administered to students in a paper and pencil format. The range of scores for this variable will be from 22-88. A score of 22 indicates no anxiety related to mathematics, while a score of 88 indicates the highest possible level of anxiety. As the scores increase from 22, they indicate higher levels of anxiety. Internal consistency of scores, with the participants of this study, will be assessed using Cronbach’s alpha.

**Predictor Variables**

The goal of a regression analysis was to determine the least number of variables that would give the strongest prediction of the criterion variable (Tabachnick & Fidell, 2007). The predictor variables that were selected must include all of the possible variables that could contribute to the model, or the regression equation may not be an accurate reflection of the predictability of the criterion variable (Tabachnick & Fidell, 2007). Therefore, the “smallest reliable, uncorrelated set” (Tabachnick & Fidell, 2007, p. 122) of variables, that covered all aspects of the criterion variable, represented the ideal number of variables).
**Demographics.** The information for the demographic variables was collected from the secretarial staff in the school’s front office. The school administration software and online gradebook, ASPEN, was utilized to generate reports with this specific information for each of the participating classes. This information was received from the parent or guardian that enrolled each child in the school. The demographics included gender, race/ethnicity, and free/reduced lunch status to serve as a way to indicate socioeconomic status. Gender had two levels including male and female. Male was entered into the data analysis software as a 0 and female was entered as the value 1. Race and ethnicity had five different levels. The levels will be Caucasian, African-American, Hispanic, Asian, Multi-racial, or Other, which are the options on student enrollment sheets. Caucasian was denoted by 0, African-American was given the number 1, Hispanic was entered as 2, Asian as 3, Multi-racial students were denoted with a 5, and those who indicated Other on their enrollment sheet were denoted by the number 6. Students that did not indicate a race or ethnicity on their enrollment sheets were indicated by the number 7. Finally, socioeconomic status was a variable with two different levels. Students that were not receiving any government lunch program support received a 1, students with a free or reduced lunch status were given a 2. These variables were all dummy coded in order to be properly analyzed, using the Statistical Package for Social Sciences (SPSS) data analysis software (Warner, 2013).

**Prior achievement.** Prior achievement for this study was determined by entering two predictors into the second block of the hierarchical analysis. Both of the measures consisted of archived student achievement data. The first measure was each student’s 2014 Georgia Criterion-Referenced Competency Test (GCRCT) score for mathematics. Student scores ranged anywhere from 750-990. Higher numbers were indicative of greater achievement on this test. The second
measure of student achievement was student yearly math average, from Spring 2014. This was a percentile score ranging from 0-100.

**Multiplication fact fluency.** Multiplication fact fluency was tested using an Aimsweb fact fluency progress monitoring probe. The multiplication fact fluency probe that was given tested basic multiplication facts that were a single digit factor multiplied by another single digit factor. Students were assessed on a combination of facts zero through nine. These probes were graded on a digits correct per two minutes (DC2M) scale. This scoring method has been used frequently when determining fact fluency. Test-retest reliability for DC2M has resulted in a reliability coefficient of .80 (Burns, VanDerHeyden & Jiban, 2006). The minimum score for the multiplication facts fluency is zero for those who are unable to answer any questions correct in two minutes. There is no maximum score as students were given too many questions to finish in two minutes. Each digit that was written correctly counted as a point. For example, for the problem 6 X 2, if students answered 10, they were given one point for having one as a correct digit in the answer. Likewise, if they answer the same problem as 22, they were given one point for the correct digit two. A correct answer for this fact yielded two points, one for each correct digit.

Aimsweb’s fact fluency probes were chosen because of the high levels of validity and reliability. The reliability of the computation probes from Aimsweb were tested using an alternate-form, resulting in a reliability rating of .85 for fourth grade probes (Pearson, 2012). The validity of the computation probes was tested with a correlation study using the Group Mathematics Assessment and Diagnostic Evaluation (G-MADE). The tests were done across the United States for first, third, and eighth grade (Pearson, 2012). The criterion validity results were \( r = .84 \) for first grade, \( r = .73 \) for third grade, and \( r = .76 \) for eighth grade (Pearson, 2012).
Mathematics problem-solving fluency. Mathematics problem solving was tested by using students’ scores on Aimsweb’s (ECBM) for mathematics. These tests were taken in a computerized format and scored by the computer as well. Scores ranged from 0 correct to 50. Expert validation has been done by the school district’s curriculum department and has been determined to be an appropriate measure of student’s current level of mathematics performance as it relates to problem solving within the curriculum that is being taught. Alternate form reliability resulted in a range of .92-.97 (rti4success.org), showing high reliability. Concurrent validity for the ECBM was tested for the state of Georgia, using the Georgia Criterion Referenced Competency Test. Validity had a range of .35-.37. Criterion validity also correlated with the end of the year test in Illinois (Pearson, 2012). The correlation for fourth grade probes ranged from .60-.67 (Pearson, 2012).

Math confidence. The math confidence of students was measured by utilizing the math confidence subscale of the abbreviated Attitudes toward Mathematics Inventory (ATMI). This subscale focused on math confidence and required students to respond to statements on a five-point Likert scale, with responses from strongly agree to strongly disagree. The scores for the scale ranged anywhere from 15-75, with higher scores indicating higher levels of math confidence and low scores indicating lower math confidence. The shortened ATMI was shown to have good internal consistency over all ($\alpha = .93$), as well as for the individual subscales which has a mean score of $\alpha = .87$. The test-retest reliability was done over a one month period with high reliability ($r = .75$).

Procedures

Before beginning any part of the data collection for this study, the researcher gained approval by submitting the appropriate paperwork to the Institutional Review Board (IRB) to
gain written approval to begin data collection. Upon receipt of IRB approval, the researcher contacted the appropriate authorities at the district level, specifically the director of student assessment, in order to discuss the study and gain permission to access the student data and research students at each location. The researcher then met with the principals at each site to discuss the details of the study and gain permission to use fourth grade students for data collection. After gaining principal approval, the researcher emailed all fourth grade teachers at the settings and asked for them to allow their students to participate in the study. Teachers were offered a $25 gift card for their cooperation in the study, encouragement of students in returning of consent/assent forms, and allowing survey administration to have scheduled time with their students. Once teachers agreed to participate, letters were sent home with the students, in order to secure consent and assent, that explained the purpose of the survey and that the students would receive a candy incentive if they returned their signed form, whether or not they chose to participate. Once each form was returned to the homeroom teacher, the permission forms were given to the researcher. The archival data from problem solving probes and demographics were to be retrieved by the school staff with access to the archived data on the school’s shared server. After an acceptable amount of participants returned consent/assent forms, teachers scheduled a day for their students to take the math anxiety and confidence surveys, and fact fluency probes. These surveys were administered during these scheduled days, during the same week from 8:00-10:00 am.

The surveys were administered by the researcher using a script that was read verbatim. Inter-rater reliability was not a concern because of the nature of the measures. The fact fluency probe and the surveys had no level of interpretation in the scoring. Each test was scored twice, once by the researcher and once by a colleague to prevent overlooking any accidental scoring
errors. Student data and scores were linked by their student identification numbers and their names were not included in the data.

Data was then recorded in SPSS in order to further analyze using the regression statistical analysis. All student data was linked according to their student identification numbers in order to maintain a high level of anonymity. All data was locked in a cabinet, to which only the researcher had access, to make sure information was kept secure.

In the event that there were fourth grade teachers that are not willing to permit their students to participate, another site was secured to be a backup. The additional school site was similar in size and demographics to the desired research locations. Due to a prior work relationship with the researcher and the administration of the backup school, access was obtainable. This additional research setting was not utilized because the first two locations yielded a large enough sample size.

Data Analysis

The data analysis for this study was hierarchical regression. In order to further validate the decision to use predictive correlation with multiple regression analysis, Table 3.2 shows studies that have used similar research design and analysis to show relationships between variables including math anxiety.
Table 3.2

*Studies Using Similar Design and Analysis*

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>Variables</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erden &amp; Akgul</td>
<td>2010</td>
<td>Math anxiety, perceived social support from teacher, math achievement</td>
<td>Multiple regression</td>
</tr>
<tr>
<td>Galla &amp; Wood</td>
<td>2012</td>
<td>Multidimensional anxiety, emotional self-efficacy, math performance</td>
<td>Moderated regression</td>
</tr>
<tr>
<td>Haynes, Mullins, &amp; Stein</td>
<td>2004</td>
<td>Perceived support and methods of high school teachers, perceived support and methods of college teachers, time since high school, perceived math ability, ACT scores, text anxiety, gender, number of colleges attended</td>
<td>Multiple regression</td>
</tr>
<tr>
<td>Legg &amp; Locker</td>
<td>2009</td>
<td>Math performance, math anxiety, metacognition</td>
<td>Multiple regression</td>
</tr>
<tr>
<td>Nunez-Pena, Pellicioni, &amp; Bono</td>
<td>2013</td>
<td>Final grades, math anxiety, math attitudes</td>
<td>Stepwise regression</td>
</tr>
</tbody>
</table>

In hierarchical regression, sometimes called sequential regression, the predictor variables were entered in different steps or groups that were determined by the researcher (Warner, 2013; Rovai et al., 2013). This was the most appropriate analysis because it allowed all of the predictor variables to be related individually with the criterion variable, as well as determining their relationship as a group with the criterion variable. Entering the variables in blocks, as in hierarchical regression, was the best way to examine these main and interaction effects with the criterion variable that was being studied. It also permitted the researcher to control the order in which the variables were entered, which allowed the predictive analysis to occur (Warner, 2013).
Ultimately, the benefit of a multiple regression analysis was that the predictive relationship between individual variables and the criterion variable could be determined, along with the predictive relationship of the combination of all predictor variables.

Hierarchical regression differed from standard regression in that it treats variables differently or unequally (Warner, 2013). The variables in hierarchical regression are entered in steps, or blocks, that are determined by the researcher during data analysis (Warner, 2013). Standard regression analyzes all of the variables simultaneously, while hierarchical regression allows for the variables to be analyzed unequally and still allow for different interactions and controls as each block is entered (Warner, 2013). As the variables were added to the analysis in blocks, it enabled them to be analyzed in terms of what they added to the prediction of the criterion variable (Warner, 2013). The order in which the variables were entered into the data analysis had to be justified. The different treatment of variables was justified by “theory, astute observation, good hunches, or sometimes by the careful examination of the distribution of residuals” (Tabachnick & Fidell, 2007, p. 122). It is also possible that decisions about order of variable entry are arbitrary (Warner, 2013). Considerations for order of variable entries are often logical or theoretical. A variable that is considered to be causally prior or have greater theoretical significance would likely be entered in earlier blocks (Tabachnick & Fidell, 2007).

In this study the demographic and prior achievement variables were entered into the analysis in the first two blocks. These variables have been established as having a relationship with mathematics anxiety and served as control variables for this study. The variables that were entered into the equation first were controlled, allowing for the change in the prediction when including additional variables to be analyzed (Tabachnick & Fidell, 2007). The next block included the multiplication fact fluency variable. This was thought to occur prior to problem
solving ability and math confidence levels and therefore was entered into the equation before these other variables. The fourth block included math problem solving. This variable was included after fact fluency was controlled, which helped determine whether or not problem solving had any additional significance in predicting mathematics anxiety. The final block was math confidence which was determined based on the theoretical framework. Theoretically, math confidence levels may be a result of students’ multiplication fact fluency and problem solving ability.

Hierarchical regression required the testing of assumptions that is done during preliminary data screening (Warner, 2013). The first step in data screening was to determine the normality of the distribution of each predictor and criterion variable (Warner, 2013). In order to determine whether or not the assumption was tenable, an individual histogram was completed for each of these variables (Warner, 2013). Additionally, all quantitative variables were paired and then tested for a linear relationship using a scatter plot (Warner, 2013). Each predictor variable was tested to determine if it had a linear relationship with the criterion variable. A screening for linear relationships was also checked between the criterion variable and the collective group of predictor variables. This was done using scatterplots and partial regression plots. Once the assumption of a linear relationship was tested, the pairs were also tested for homogeneity of variance, and extreme outliers (Warner, 2013). In the case that any extreme outliers were found, the researcher had to determine if the outliers should be excluded from the analysis. Proper specification of the regression model was another important assumption of hierarchical regression. This refers to the inclusion of all relevant predictor variables and not omitting one that would be an important part of the model (Rovai et al., 2013). If important predictor variables were left out of the analysis, the results would be misleading and show a false
attribution of the selected variables (Rovai et al., 2013). The sample size was an important assumption due to the use of hierarchical regression. The sample size needed to be $N \geq 50 + 8m$ when multiple correlation was tested and $N \geq 104 + m$ when the relationship of individual predictor variables are being tested (Tabachnick & Fidell, 2007). In each case, $m$ was equal to the number of predictor variables (Tabachnick & Fidell, 2007). If the analyst desired to determine both of these relationships, it is best to figure out optimal sample size of each type of analysis and then use the larger of the two numbers as the ideal sample size (Tabachnick & Fidell, 2007). Other research conventions suggested that a minimum of 100 subjects be included when multiple regression is used for the analysis (Warner, 2013).

Additional assumptions that were checked are the absence of multicollinearity and singularity, the normality, linearity, and homoscedasticity of residuals, the independence of errors, and the absence of outliers in the solution (Tabachnick & Fidell, 2007). Multicollinearity occurs when two of the predictor variables are highly correlated with each other, which may lead to an inflated regression coefficient. Multicollinearity is checked by examining the correlation coefficients and the tolerance values for these variables (Tabachnick & Fidell, 2007). If multicollinearity is detected, the researcher would use logic rather than statistics to determine which of the variables may need to be removed from the equation (Tabachnick & Fidell, 2007).

The residuals were examined simultaneously for normality, linearity, and homoscedasticity in the regression analysis. These assumptions were tested using residual scatterplots in which the residuals should be normally distributed around the predicted criterion variable (Tabachnick & Fidell, 2007). These scatterplots should also show that the residuals are linear and that the variance of residuals are the same for each of the predicted criterion values. If all of the residual assumptions are met, the shape of the scatterplot should be similar to that of a
rectangle (Tabachnick & Fidell, 2007). Homoscedasticity was examined to ensure that the standard deviations of error was nearly equal for all of the predicted criterion values. The band surrounding the scatterplot should be approximately equal in width at all of the values for the assumption to be met (Tabachnick & Fidell, 2007).

Independence of errors was tested through the examination of residuals, as well. This indicates that all of the errors in the predictor of the criterion variables are independent of one another (Tabachnick & Fidell, 2007). The Durbin-Watson statistic is then used to measure the correlation of errors across the cases that have been entered in sequence. If this test indicates that there is significant correlation between errors in the sequenced cases, nonindependence of errors is present (Tabachnick & Fidell, 2007). Autocorrelation of errors may lead to a Type 1 error if they are positively correlated, or a low of power when negative correlation is indicated (Tabachnick & Fidell, 2007).

Finally, the absence of outliers in the solution was an assumption that had to be tested in hierarchical regression analysis. There was an expectation of some outliers in the solution for which the regression equation was not a good fit (Tabachnick & Fidell, 2007). Cook’s distance was used to identify these outliers. A histogram will screen for the normality of the residuals, or errors (Tabachnick & Fidell, 2007).

When reporting the results of hierarchical regression the multiple correlation coefficient is stated (Gall et al., 2007). This multiple correlation coefficient ($R$) is a measure of the relationship between a predictor variable, or any combination of predictor variables, with the stated criterion variable (Gall et al., 2007). The reporting of $R$ gave an idea of how much of the criterion variable could be related to the predictor variable. As a greater number of variables were added to the regression, the expectancy was that the value of $R$ would continue to increase
When the value of $R$ is squared it is known as the coefficient of determination (Gall et al., 2007). The coefficient of determination ($R^2$) indicated the change in the criterion variable that can be explained or related to the adding of another predictor variable (Gall et al., 2007). The adjusted $R^2$ was also reported in order to correct any bias that may have been a part of the sample and create a better estimation of what results could be expected when generalizing to a larger population. According to Green and Salkind (2011), non-experimental studies should utilize the random-effects model for assumption testing. Table 3.3 shows the items that were included in the statistical analysis results after performing a hierarchical regression analysis, including assumption testing.

### Table 3.3

**Items Included in the Statistical Analysis Results**

<table>
<thead>
<tr>
<th>Test</th>
<th>Reported As</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assumption</td>
<td>Histogram or Shapiro-Wilk</td>
<td>Check the assumption that variables are multivariately normally distributed (Green &amp; Salkind, 2011).</td>
</tr>
<tr>
<td>Assumption</td>
<td>Scatterplot</td>
<td>Scatterplots between the predictor and criterion variables should be analyzed to check for nonlinearity (Green &amp; Salkind, 2011).</td>
</tr>
<tr>
<td>Assumption</td>
<td>Cook’s $d$</td>
<td>Checks for any extreme outliers in the data.</td>
</tr>
<tr>
<td>Descriptive</td>
<td>$SD$ and $M$</td>
<td>These descriptives show the average score and how much scores deviate from the mean.</td>
</tr>
<tr>
<td>Correlation Coefficient</td>
<td>Pearson’s $r$</td>
<td>This value represents the correlation coefficient between the predictor and criterion variables.</td>
</tr>
<tr>
<td>Regression Model Summary</td>
<td>$R$</td>
<td>$R$ represents the multiple correlation coefficient. The multiple correlation coefficient represents the correlation between what the expected or predicted values of the criterion and the actual criterion values. Values range from 0-1. Higher</td>
</tr>
</tbody>
</table>
### Regression Model Summary

| **R²** | values are indicative of a closer correlation between predicted and actual criterion values.  

*R²* represents the coefficient of determination.  

This is the variance of the criterion variable that is explained by the predictor variables. |
|--------|-------------------------------------------------|

| **Adjusted R²** | Adjusted *R²* is especially important with small samples and is an adjusted value that helps to avoid inflated values due to large amount of predictor variables.  

This value is an estimate of the effect size. |
|------------------|--------------------------------------------------------------------------------|

| **R² Change** | This value is the same as what is found in the *R²* column.  

The *R²* change is calculated by subtracting the prior *R²* value from the current *R²* value to indicate any change occurring from the addition of the new predictor. |
|----------------|--------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th><strong>Sig. F Change</strong></th>
<th>This part of the summary indicates whether the change is statistically significant, <em>p</em> &lt; .005.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>p value</strong></th>
<th>When <em>p</em> &lt; .05, the results of the analysis are statistically significant.</th>
</tr>
</thead>
</table>

| **F ratio** | This tests the ratio of the mean sum of squares for the regression to the mean sum of squares for the residuals.  

This tests the fit of the model for the given data. |
|-------------|--------------------------------------------------------------------------------|

<table>
<thead>
<tr>
<th><strong>df</strong></th>
<th>The degrees of freedom for each regression model.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Regression Equation</strong></th>
<th>The regression equation shows the degree to which the criterion variable can be predicted by the predictor variables.</th>
</tr>
</thead>
</table>

The data collected was entered into the statistical analysis program in separate blocks.  

The blocks are shown in Table 3.4 below.  
When utilizing hierarchical regression, it is typical for the variables being examined to be entered into the analysis software in an order that is
determined by the researcher (Tabachnick & Fidell, 2007). The variables may be ordered according to logical or theoretical considerations (Tabachnick & Fidell, 2007). Variables that have the presumption of being causally prior were given a higher priority when it came to entering them into the analysis (Tabachnick & Fidell, 2007). Theoretical priority was also argued, which gave those variables a justifiable early entry into the regression analysis (Tabachnick & Fidell, 2007). Block one, in the chart below, includes the demographic variables of gender, race, and socioeconomic status. These variables are ones that students are born into and are causally prior to all other variables. The second block of predictor variables includes prior mathematics achievement levels as indicated by current mathematics average and Georgia Criterion Referenced Competency Test Scores. This block was entered into the analysis second, because students begin to experience some level of achievement as soon as they are introduced to mathematical content. The third block was entered as a score on the MASC, and the fourth block included the multiplication fact fluency and problem solving fluency scores. Theoretically, the multiplication fact fluency is related to math problem solving ability. Students who are unable to master basic facts, fluently, will have a more difficult time solving multi-step problems. See Table 3.4 for a list of the data source blocks and the order in which they will be entered into the SPSS statistical analysis software.
Table 3.4

*Data Source Blocks for Hierarchical Regression*

<table>
<thead>
<tr>
<th>Block</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Demographic Variables</td>
</tr>
<tr>
<td></td>
<td>Gender</td>
</tr>
<tr>
<td></td>
<td>Race</td>
</tr>
<tr>
<td></td>
<td>Socioeconomic Status</td>
</tr>
<tr>
<td>2</td>
<td>Prior Achievement</td>
</tr>
<tr>
<td></td>
<td>GCRCT Scores</td>
</tr>
<tr>
<td></td>
<td>Math Average</td>
</tr>
<tr>
<td>3</td>
<td>Multiplication Fact Fluency</td>
</tr>
<tr>
<td>4</td>
<td>Problem Solving Fluency</td>
</tr>
<tr>
<td>5</td>
<td>Math Confidence</td>
</tr>
</tbody>
</table>

**Limitations**

There are several limitations when using regression analysis. Regression analysis is used when relationships between variables are being explored (Tabachnick & Fidell, 2007). The relationships that are found are in no way indicating a causal relationship, which may be confusing due to the name correlation design (Tabachnick & Fidell, 2007). It is also important to consider the number of cases in the study in comparison to the number of predictor variables (Tabachnick & Fidell, 2007). A ratio of 40 to 1 is reasonable when utilizing a stepwise regression in order to make sure that the results are more likely to generalize to a larger population (Tabachnick & Fidell, 2007). This will require quite a large sample size. In this case the predictor variables are demographics, prior achievement, multiplication fact fluency, and
problem solving ability. These four predictors require a sample of at least 160 fourth grade students. Outliers can become a problem in regression, as well. The extremity of some outliers can have too great of an impact on the results (Tabachnick & Fidell, 2007). One way to screen for outliers is by conducting outlier tests such as Mahalanobis distance test or Cook’s $d$ (Tabachnick & Fidell, 2007). Another limitation of the study is the external validity. The results of the study may not be generalizable to populations that are from other grade levels or geographic areas.
CHAPTER FOUR: FINDINGS

Introduction

This study examined the predictive relationship of multiplication fact fluency, problem-solving ability, and math confidence with mathematics anxiety, while controlling for demographics and prior achievement. Prior achievement and demographic variables were controlled in order to determine whether or not the addition of subsequent variables would be a significant addition to the predictive model for mathematics anxiety. Prior achievement variables included fourth grade students’ yearly grade average for math (previous year), along with their math score for the most recent standardized test. Demographic variables that were controlled included gender, race/ethnicity, and socioeconomic status (free/reduced lunch status).

Research Questions

The research questions that were used to conduct this research were:

**RQ1:** Is there a statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence and math anxiety in fourth grade students while controlling for demographics and prior achievement?

**RQ1a:** Is there a statistically significant contribution of the demographics variables in predicting math anxiety?

**RQ1b:** Is there a statistically significant contribution of prior achievement in mathematics in predicting math anxiety?

**RQ1c:** Is there a statistically significant contribution of multiplication fact fluency in predicting math anxiety?

**RQ1d:** Is there a statistically significant contribution of math problem solving ability in predicting mathematics anxiety?
**RQ1e:** Is there a statistically significant contribution of math confidence in predicting mathematics anxiety?

**Hypotheses**

The following are the research hypotheses for this study:

**H$_1$:** There is a statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.

**H$_{1a}$:** There is a statistically significant contribution of demographic variables in predicting math anxiety.

**H$_{1b}$:** There is a statistically significant contribution of prior math achievement in predicting math anxiety.

**H$_{1c}$:** There is a statistically significant contribution of multiplication fact fluency in predicting math anxiety.

**H$_{1d}$:** There is a statistically significant contribution of problem solving ability in predicting math anxiety.

**H$_{1e}$:** There is a statistically significant contribution of math confidence in predicting math anxiety.

**Null Hypotheses**

The following are the null hypotheses for this study:

**H$_{01}$:** There is no statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.
There is no statistically significant contribution of demographic variables in predicting math anxiety.

There is no statistically significant contribution of prior mathematics achievement in predicting math anxiety.

There is no statistically significant contribution of multiplication fact fluency in predicting math anxiety.

There is no statistically significant contribution of problem solving ability in predicting math anxiety.

There is no statistically significant contribution of math confidence in predicting math anxiety.

**Descriptive Statistics**

The descriptive statistics below give an analysis of the mean and standard deviation for each of the quantitative variables used in this study. Mathematics anxiety ($M = 44.09$, $SD = 12.61$) was the criterion variable that was used for this study. Math confidence ($M = 53.67$, $SD = 15.26$), multiplication fact fluency ($M = 58.05$, $SD = 28.90$), Georgia Criterion-Referenced Competency Test scores ($M = 860.55$, $SD = 48.50$), problem solving ability ($M = 33.93$, $SD = 6.76$), and yearly grade averages ($M = 88.93$, $SD = 6.83$) were the quantitative predictor variables included in the analysis. These descriptive statistics are shown below in Table 4.1.
Table 4.1

Quantitative Predictor Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Anxiety</td>
<td>174</td>
<td>63.00</td>
<td>44.09</td>
<td>12.61</td>
</tr>
<tr>
<td>Math Confidence</td>
<td>174</td>
<td>56.00</td>
<td>53.67</td>
<td>15.26</td>
</tr>
<tr>
<td>Fact Fluency</td>
<td>174</td>
<td>136.00</td>
<td>58.05</td>
<td>28.90</td>
</tr>
<tr>
<td>GCRCT</td>
<td>174</td>
<td>236.00</td>
<td>860.55</td>
<td>48.50</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>174</td>
<td>31.00</td>
<td>33.93</td>
<td>6.76</td>
</tr>
<tr>
<td>Grades</td>
<td>174</td>
<td>29.00</td>
<td>88.93</td>
<td>6.83</td>
</tr>
</tbody>
</table>

Descriptive statistics also include the frequencies for each of the demographic variables that were controlled in this study. Table 4.2 shows the information related to gender, Table 4.3 shows race/ethnicity, and Table 4.4 displays the results of socioeconomic status data for the participants of the study. Table 4.2 also indicates that the number of participants, \( N = 174 \), was an adequate sample size for the design and analysis used in this study. The sample of participants used in the study (\( N = 174 \)) included 37.9% fourth grade male (\( n = 66 \)) and 62.1% fourth grade female (\( n = 108 \)) students. The different races or ethnicities represented in this study included 68.4% Caucasian (\( n = 119 \)), 10.3% African-American (\( n = 18 \)), 16.1% Hispanic (\( n = 28 \)), 2.3% Asian (\( n = 4 \)), 1.7% Multi-Racial (\( n = 3 \)), and 1.1% American-Indian (\( n = 2 \)) students. According to the United States Census Bureau (2013), the percentages of the race and ethnicity of the general nationwide population are as follows: White, 77.7%; Black, 13.2%; American Indian, 1.2%; Asian 5.3%, Multiracial, 2.4%; and Hispanic 17.1%. This indicates that the demographics represented in the sample population for this study are close to the diversity of
the population nationwide. Finally, the demographic variable of socioeconomic status was indicated by each student’s free/reduced lunch status. The sample indicated those that were receiving free/reduced lunch was 24.7% \((n = 43)\) and those who were receiving no financial assistance with regards to government lunch was 75.3% \((n = 131)\). This indicates that approximately one-fourth of the sample was receiving financial assistance in this manner, and is considered to be the low socioeconomic status group for the purposes of this study.

Table 4.2

*Gender Frequencies*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>66</td>
<td>37.9</td>
</tr>
<tr>
<td>Female</td>
<td>108</td>
<td>62.1</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 4.3

*Race/Ethnicity Frequencies*

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>119</td>
<td>68.4</td>
</tr>
<tr>
<td>African-American</td>
<td>18</td>
<td>10.3</td>
</tr>
<tr>
<td>Hispanic</td>
<td>28</td>
<td>16.1</td>
</tr>
<tr>
<td>Asian</td>
<td>4</td>
<td>2.3</td>
</tr>
<tr>
<td>Multi-Racial</td>
<td>3</td>
<td>1.7</td>
</tr>
<tr>
<td>American Indian</td>
<td>2</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 4.4

Socioeconomic Status Frequencies (free/reduced lunch)

<table>
<thead>
<tr>
<th>Socioeconomic Status</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free/Reduced Lunch</td>
<td>43</td>
<td>24.7</td>
</tr>
<tr>
<td>Valid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not Free/Reduced Lunch</td>
<td>131</td>
<td>75.3</td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Results
Assumption Testing

The following assumptions were addressed for the correlation and multiple regression analysis: normality, homogeneity of variance, multicollinearity, absence of outliers, independence of errors, and the examination of residuals.

Normality

Preliminary data screening was used in order to make sure that each of the predictor and criterion variables was normally distributed. For this particular data set, a histogram was used to make this determination. Each of the predictor variables, as well as the criterion variable, showed a relatively normal distribution. The problem solving, math confidence, and grades variables showed a distribution that was slightly negatively skewed. The fact fluency and math anxiety variables were slightly positively skewed.
Figure 4.1. Math Anxiety Distribution  
Figure 4.2. Math Confidence Distribution  
Figure 4.3. Fact Fluency Distribution  
Figure 4.4. GCRCT Distribution  
Figure 4.5. Grades Distribution  
Figure 4.6. Problem Solving Distribution
After each histogram was visually analyzed, a statistical test of normality was also conducted. The test used was the Shapiro-Wilk test. Using the Shapiro-Wilk test, each of the variables showed significance, \( p < .05 \) (Field, 2005). This indicates that each of the distributions may vary slightly from a normal distribution. The use of Q-Q plots show the line of normal distribution and where the sample values actually fall in regards to normality. The plots showed that while there is slight variation from the normal distribution, it doesn’t appear to be significant. Therefore, the assumptions of normality are tenable for this data.

**Homoscedasticity and Linearity**

Each predictor variable was then paired with the criterion variable to determine whether or not the two variables had a linear relationship. Scatterplots were used to determine this assumption. The scatterplots showed that math confidence and math anxiety had a positive linear relationship. However, the other four variables had a negative linear relationship.

**Homogeneity of Variance**

The next assumption test was conducted in order to examine homogeneity of variance. This assumption means that while you are changing one level of a variable, the variance in the other variables shouldn’t change (Field, 2005). The values of the variables may change, but the variance should not. This can be tested using graphs or Levene’s test. The previously examined scatterplots that show paired variables can be used to determine if these variables pass the homogeneity of variance assumption. These plots show that the variables have the same variance regardless of the level of the other variable. Therefore, this assumption is reasonable.
Outliers

There also does not appear to be any extreme outliers that would need to be removed from the data set. The scatterplots were also used to examine the assumptions of homoscedasticity and linearity. These assumptions were both determined to be plausible.

Multicollinearity

The absence of multicollinearity assumption was examined by using the correlation coefficient for each of the pairs of variables. The correlation matrix was used to determine possible high correlations. Table 4.5 shows Pearson’s correlation coefficients for each of the variable pairs.

Table 4.5

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Math Anxiety</td>
<td>-</td>
<td>.166*</td>
<td>.028</td>
<td>.047</td>
<td>-.194*</td>
<td>-.318**</td>
<td>-.151*</td>
<td>-.354**</td>
<td>-.691**</td>
</tr>
<tr>
<td>2. Gender</td>
<td>.166*</td>
<td>-</td>
<td>.167*</td>
<td>-.009</td>
<td>.032</td>
<td>-.040</td>
<td>.083</td>
<td>-.139</td>
<td>-.138</td>
</tr>
<tr>
<td>3. Race</td>
<td>.028</td>
<td>.167*</td>
<td>-</td>
<td>-.355**</td>
<td>-.149</td>
<td>-.210**</td>
<td>-.039</td>
<td>-.253**</td>
<td>-.036</td>
</tr>
<tr>
<td>4. SES</td>
<td>.047</td>
<td>-.009</td>
<td>-.355**</td>
<td>-</td>
<td>.188*</td>
<td>.235**</td>
<td>.000</td>
<td>.181*</td>
<td>-.013</td>
</tr>
<tr>
<td>5. Grades</td>
<td>-.194*</td>
<td>.032</td>
<td>-.149</td>
<td>.188*</td>
<td>-</td>
<td>.654**</td>
<td>.326**</td>
<td>.590**</td>
<td>.376**</td>
</tr>
<tr>
<td>6. GCRCT</td>
<td>-.318**</td>
<td>-.040</td>
<td>-.210**</td>
<td>.235**</td>
<td>.654**</td>
<td>-</td>
<td>.493**</td>
<td>.769**</td>
<td>.377**</td>
</tr>
<tr>
<td>7. Fact Fluency</td>
<td>-.151*</td>
<td>.083</td>
<td>-.039</td>
<td>.000</td>
<td>.326**</td>
<td>.493**</td>
<td>-</td>
<td>.423**</td>
<td>.327**</td>
</tr>
<tr>
<td>8. Problem Solving</td>
<td>-.354**</td>
<td>-.139</td>
<td>-.253**</td>
<td>.181*</td>
<td>.590**</td>
<td>.769**</td>
<td>.423**</td>
<td>-</td>
<td>.415**</td>
</tr>
<tr>
<td>9. Math Confidence</td>
<td>.683**</td>
<td>.137</td>
<td>.044</td>
<td>.057</td>
<td>-.371**</td>
<td>-.362**</td>
<td>-.305**</td>
<td>-.385**</td>
<td>-</td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

The information in Table 4.5 indicates that the variables of math anxiety and math confidence have the highest correlation, $r = -.69$. Typically very high correlations that are...
concerning are at the .80-.90 value (Field, 2005). However, reporting the variance inflation factor (VIF) and tolerance statistic help determine whether or not multicollinearity is a bias in the regression summary model (Field, 2005). A VIF value of 10 is the level at which concern for bias is indicated (Field, 2005). Also, the reciprocal of VIF, which is the tolerance statistic, indicates cause for concern when the value is below .1 (Field, 2005). Table 4.6 shows the results of this analysis. The greatest VIF value for the final block of the model is 3.186, while the smallest indicated tolerance statistic is .31. This indicates that multicollinearity is not biasing the model and that the assumption of the absence of multicollinearity is reasonable.

Table 4.6

Collinearity Statistics

<table>
<thead>
<tr>
<th>Unstandard Coefficients</th>
<th>Standard Coefficients</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>β</td>
</tr>
<tr>
<td>Constant</td>
<td>84.2</td>
<td>16.247</td>
<td>.518</td>
</tr>
<tr>
<td>Gender</td>
<td>.85</td>
<td>1.469</td>
<td>.033</td>
</tr>
<tr>
<td>Race</td>
<td>-.158</td>
<td>.704</td>
<td>-.013</td>
</tr>
<tr>
<td>SES</td>
<td>1.80</td>
<td>1.728</td>
<td>.062</td>
</tr>
<tr>
<td>GCRCT</td>
<td>-.048</td>
<td>.025</td>
<td>-.187</td>
</tr>
<tr>
<td>Grades</td>
<td>.346</td>
<td>.137</td>
<td>.188</td>
</tr>
<tr>
<td>Fact Fluency Problem Solving Math Confidence</td>
<td>.064</td>
<td>.028</td>
<td>.147</td>
</tr>
<tr>
<td>Problem Solving Math Confidence</td>
<td>-.200</td>
<td>.167</td>
<td>-.107</td>
</tr>
<tr>
<td>Math Confidence</td>
<td>-.569</td>
<td>.051</td>
<td>-.689</td>
</tr>
</tbody>
</table>

The absence of outliers was examined by using Cook’s distance test. Cook’s distance test is able to measure how one particular case may be impacting the overall model. The outcome of this test was a minimum of $d = .000$ and a maximum value of $d = .098$. This
indicates that there are no single cases in this data set that are outliers that would impact the overall analysis of data. The examination of residuals eliminates the concern about linearity, normality, and homoscedasticity. These residuals are examined using a residual plot that is seen in Figure 4.7. The results of the residual plot shows that the assumptions of linearity, normality, and homoscedasticity of residuals was met. This is because of the rectangular shape of residuals around the predicted criterion value.

![Scatterplot](image)

**Figure 4.7.** Residual Plot

Table 4.7 is additional confirmation of these results. The mean of the residuals for the data was .00. This indicates that the positive and negative residuals balance out to an average of zero, indicating that the residuals are typical.
The final data screening was an additional examination of residuals. This was done using the Durbin-Watson statistic. This statistic is used to determine whether or not there is a correlation between the errors. Independence of errors is an important assumption of this analysis. The Durbin-Watson test yielded a value of 1.95. A value of 2 indicates that there is independence of errors. A value of 1.95 makes the independence of errors a tenable assumption.

**Correlation of Predictor Variables and Mathematics Anxiety**

The results of the correlation matrix show the relationships between each of the variables. Of particular interest are the relationships between each of the individual predictor variables with the criterion variable, mathematics anxiety. The first block of variables entered into the model included demographic variables. Individually, these variables were gender, race, and socioeconomic status. Each of these demographic variables had a low positive correlation with mathematics anxiety. Gender had a low positive correlation of $r = .166$, race had a correlation value of $r = .028$, and socioeconomic status had a very low positive correlation of $r = 0.47$. The second block of data entry for this study included prior achievement variables. The prior achievement variables for this study were the math score from Georgia Criterion-Reference Competency Test (GCRCT) in April 2014 and each student’s yearly math average from Spring 2014. Mathematics anxiety and GCRCT scores had a medium negative correlation of $r = -.318$. 

---

**Table 4.7**

*Residuals Statistics*

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>$M$</th>
<th>$SD$</th>
<th>$N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted Value</td>
<td>26.1855</td>
<td>67.1110</td>
<td>44.0862</td>
<td>9.11616</td>
<td>174</td>
</tr>
<tr>
<td>Residual</td>
<td>-28.07936</td>
<td>23.22917</td>
<td>.00000</td>
<td>8.71072</td>
<td>174</td>
</tr>
<tr>
<td>Standard Predicted Value</td>
<td>-1.964</td>
<td>2.526</td>
<td>.000</td>
<td>1.000</td>
<td>174</td>
</tr>
<tr>
<td>Standard Residual</td>
<td>-3.148</td>
<td>2.604</td>
<td>.000</td>
<td>.977</td>
<td>174</td>
</tr>
</tbody>
</table>
This means that as the GCRCT scores had higher values, the level of mathematics anxiety was lower. The reverse is that those with lower GCRCT scores, had higher levels of mathematics anxiety. The final math grades and math anxiety for students had a small negative correlation of \( r = -0.194 \). The third block included only one predictor variable, which was multiplication fact fluency. There was a low negative correlation (\( r = -0.151 \)) between multiplication fact fluency and mathematics anxiety. Problem solving ability was entered into the model next. This predictor had a medium negative correction with mathematics anxiety, with a value of \( r = -0.354 \). This indicates that students with higher problem solving scores, had lower mathematics anxiety scores. Also, those with low scores on problem solving, would have a higher level of mathematic anxiety. The final predictor variable for this study was math confidence. This variable resulted in a high negative correlation of \( r = -0.691 \).

The relationships between the predictor and criterion variables are important to analyze. However, the correlations between some of the predictor variables could give insight as to what type of statistically significant relationships exist between predictors. Math confidence had a medium positive correlation with GCRCT scores (\( r = 0.377 \)), multiplication fact fluency (\( r = 0.327 \)), problem solving (\( r = 0.415 \)), and yearly math grades (\( r = 0.376 \)). Georgia Criterion Referenced Competency Scores for math had a high positive correlation with multiplication fact fluency (\( r = 0.493 \)), problem solving (\( r = 0.769 \)), and yearly math grades (\( r = 0.654 \)). Multiplication fact fluency had a medium positive correlation with problem solving (\( r = 0.423 \)) and yearly math grades (\( r = 0.326 \)). Finally, problem solving had a high positive correlation with grades (\( r = 0.590 \)). These values can be seen in Table 4.8, which shows the correlations for each of the variables included in this study.
Table 4.8

Pearson Correlations

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Math Anxiety</td>
<td></td>
<td>-166</td>
<td>028</td>
<td>047</td>
<td>-194</td>
<td>-318</td>
<td>-151</td>
<td>-354</td>
<td>-691</td>
</tr>
<tr>
<td>2. Gender</td>
<td>.166</td>
<td></td>
<td>-167</td>
<td>-009</td>
<td>032</td>
<td>-040</td>
<td>083</td>
<td>-139</td>
<td>-138</td>
</tr>
<tr>
<td>4. SES</td>
<td>.047</td>
<td>-.009</td>
<td>-.355</td>
<td></td>
<td>188</td>
<td>235</td>
<td>000</td>
<td>.181</td>
<td>-.013</td>
</tr>
<tr>
<td>5. Grades</td>
<td></td>
<td>.032</td>
<td>-.149</td>
<td>.188</td>
<td></td>
<td>-.654</td>
<td>.326</td>
<td>.590</td>
<td>.377</td>
</tr>
<tr>
<td>6. GCRCT</td>
<td></td>
<td>-.040</td>
<td>-.210</td>
<td>.235</td>
<td>.654</td>
<td></td>
<td>.493</td>
<td>.769</td>
<td>.376</td>
</tr>
<tr>
<td>7. Fact Fluency</td>
<td></td>
<td>.083</td>
<td>-.039</td>
<td>.000</td>
<td>.326</td>
<td>.493</td>
<td></td>
<td>.423</td>
<td>.327</td>
</tr>
<tr>
<td>8. Problem</td>
<td></td>
<td>-.139</td>
<td>-.253</td>
<td>.181</td>
<td>.590</td>
<td>.769</td>
<td>.423</td>
<td></td>
<td>.415</td>
</tr>
<tr>
<td>9. Math</td>
<td></td>
<td>.683</td>
<td>.137</td>
<td>.044</td>
<td>.057</td>
<td>-.371</td>
<td>-.362</td>
<td>-.305</td>
<td>-.385</td>
</tr>
<tr>
<td>Confidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results of the Hierarchical Regression Model

The primary research question for this study sought to examine the existence of a relationship between multiplication fact fluency, problem solving, and math confidence with mathematics anxiety while controlling for demographic (i.e., gender, race/ethnicity, and socioeconomic status) and prior achievement variables (i.e., GCRCT score and yearly math averages). These variables were entered into the data analysis in five blocks which resulted in five different models. The five different models for this study are found in Table 4.9.
Table 4.9

Models for Hierarchical Regression

<table>
<thead>
<tr>
<th>Model</th>
<th>Predictor Variables</th>
<th>Criterion Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>gender + race + ses</td>
<td>= math anxiety</td>
</tr>
<tr>
<td>2</td>
<td>gender + race + ses + GCRCT + grades</td>
<td>= math anxiety</td>
</tr>
<tr>
<td>3</td>
<td>gender + race + ses + GCRCT + grades + fact fluency</td>
<td>= math anxiety</td>
</tr>
<tr>
<td>4</td>
<td>gender + race + ses + GCRCT + grades + fact fluency +</td>
<td>= math anxiety</td>
</tr>
<tr>
<td></td>
<td>problem solving</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>gender + race + ses + GCRCT + grades + fact fluency +</td>
<td>= math anxiety</td>
</tr>
<tr>
<td></td>
<td>problem solving + math confidence</td>
<td></td>
</tr>
</tbody>
</table>

Each of these models will be examined separately in order to determine the contribution that each had in the prediction of mathematics anxiety. The models are a representation of the overall research question, as well as the sub-questions for this study. The results found in each of these five models will be used to determine whether or not each null hypothesis can be rejected or will fail to be rejected.

Model One

Model One for this study represents the predictor demographic variables of gender, race, and socioeconomic status. The model examined how these demographic variables related to mathematics anxiety. The research question for this model was: “Is there a statistically significant contribution of the demographic variables in predicting math anxiety?” Therefore the associated null hypothesis was: “There is no statistically significant contribution of demographic variables in predicting math anxiety.” Model One was not significant in predicting mathematics
anxiety. The results of the overall model were $F (3, 171) = 1.761, p = .15$, which represented an overall variance of 3% in predicting math anxiety.

**Model Two**

Model Two for this study added two prior achievement predictor variables. These variables were GCRCT math scores and yearly math average. These two variables were entered into the model simultaneously in order to get an overall picture of what prior achievement added to the prediction of mathematics anxiety. The variables were examined separately for correlations, but their combined value gives a better overall picture of students’ prior achievement than one of the variables would alone. The model examined how these prior achievement variables added to the model for predicting mathematics anxiety. The research question for this model was: “Is there a statistically significant contribution of prior achievement in mathematics in predicting math anxiety?” Therefore the associated null hypothesis was: “There is no statistically significant contribution of prior achievement variables in predicting math anxiety.” Model Two was significant in predicting mathematics anxiety. The results of the overall model were $F (5, 168) = 5.520, p = .00$, which represented an overall variance of 11.1% for prior achievement in predicting math anxiety.

**Model Three**

Model Three controlled for all of the demographic and prior achievement variables, while added a new predictor variable of multiplication fact fluency. The model examined if multiplication fact fluency contributed any significance in predicting math anxiety. The research question for this model was: “Is there a statistically significant contribution of multiplication fact fluency in predicting math anxiety?” Therefore the associated null hypothesis was: “There is no statistically significant contribution of multiplication fact fluency in predicting math anxiety.”
Model Three was found to have no significance in predicting mathematics anxiety. The results of the overall model were $F (6, 167) = 4.572, p = .00$. This overall model showed predictive significance $p = .00$, but the actual contribution that multiplication fact fluency had was $\Delta R^2$ of 0.00%. This indicates that the addition of multiplication fact fluency to the model did not contribute a significant relationship.

**Model Four**

Model Four controlled for all previously entered variables and added the predictor variable of problem solving ability. The model examined how problem solving ability contributed to the prediction of mathematics anxiety. The research question for this model was: “Is there a statistically significant contribution of problem solving ability in predicting math anxiety?” Therefore the associated null hypothesis was: “There is no statistically significant contribution of problem solving ability in predicting math anxiety.” Model Four was found to be significant in predicting mathematics anxiety. The results of the overall model were $F (7, 166) = 4.712, p = .00$, which represented an overall percentage of 16.6% and a $\Delta R^2$ value of 2.5%.

**Model Five**

Model Five was the full model for this research study. It added the final predictor variable of math confidence to the model. Again, all previously entered variables were controlled and this model focused on how math confidence related to the ability to predict mathematics anxiety. The research question for this model was: “Is there a statistically significant contribution of math confidence in predicting math anxiety?” Therefore the associated null hypothesis was: “There is no statistically significant contribution of math confidence in predicting math anxiety.” Model Five was found to be significant in predicting
mathematics anxiety. The results of the overall model were \( F(8, 165) = 22.590, p = .00 \), which represented an overall percentage of 52.3% and a \( \Delta R^2 \) value of 35.7%.

The results of each of these models can be seen in Table 4.10 and Table 4.11.

Table 4.10

*Analysis of Variance (ANOVA)*

<table>
<thead>
<tr>
<th>Model</th>
<th>Sums of Squares</th>
<th>DF</th>
<th>Mean Square</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Regression</td>
<td>828.836</td>
<td>3</td>
<td>276.279</td>
<td>1.761</td>
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<td></td>
<td>Residual</td>
<td>26674.871</td>
<td>170</td>
<td>156.911</td>
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<tr>
<td></td>
<td>Total</td>
<td>27503.707</td>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Regression</td>
<td>3881.067</td>
<td>5</td>
<td>776.213</td>
<td>5.520</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>23622.640</td>
<td>168</td>
<td>140.611</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>27503.707</td>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Regression</td>
<td>3882.104</td>
<td>6</td>
<td>647.017</td>
<td>4.574</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>23621.603</td>
<td>167</td>
<td>141.447</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>27503.707</td>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Regression</td>
<td>4559.300</td>
<td>7</td>
<td>651.329</td>
<td>4.712</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>22944.407</td>
<td>166</td>
<td>138.219</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>27503.707</td>
<td>173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Regression</td>
<td>14377.050</td>
<td>8</td>
<td>1797.131</td>
<td>22.590</td>
</tr>
<tr>
<td></td>
<td>Residual</td>
<td>13126.657</td>
<td>165</td>
<td>79.555</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>27503.707</td>
<td>173</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.11

*Model Summary*

<table>
<thead>
<tr>
<th>Model</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error of Estimate</th>
<th>Change Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>R Square Change</td>
</tr>
<tr>
<td>1</td>
<td>.174</td>
<td>.030</td>
<td>.013</td>
<td>12.526</td>
</tr>
<tr>
<td>2</td>
<td>.376</td>
<td>.141</td>
<td>.116</td>
<td>11.857</td>
</tr>
<tr>
<td>3</td>
<td>.376</td>
<td>.141</td>
<td>.110</td>
<td>11.893</td>
</tr>
<tr>
<td>4</td>
<td>.407</td>
<td>.166</td>
<td>.131</td>
<td>11.756</td>
</tr>
<tr>
<td>5</td>
<td>.723</td>
<td>.523</td>
<td>.500</td>
<td>8.919</td>
</tr>
</tbody>
</table>
Summary

This predictive correlation study, with hierarchical regression analysis, examined the relationships between multiplication fact fluency, problem solving, and math confidence with the levels of mathematics anxiety for 174 fourth grade students. The results of each of the null hypotheses are shown in Table 4.12.

Table 4.12

Summary of Tested Hypotheses

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Null Statement</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H_{01}$</td>
<td>There is no statistically significant predictive relationship between multiplication fact fluency, math problem-solving ability, math confidence, and math anxiety in fourth grade students while controlling for demographics and prior achievement.</td>
<td>51.3%</td>
<td>34.8%</td>
<td>reject</td>
</tr>
<tr>
<td>$H_{01a}$</td>
<td>There is no statistically significant contribution of demographic variables in predicting math anxiety.</td>
<td>3%</td>
<td>3%</td>
<td>fail to reject</td>
</tr>
<tr>
<td>$H_{01b}$</td>
<td>There is no statistically significant contribution of prior mathematics achievement in predicting math anxiety.</td>
<td>14.1%</td>
<td>11.1%</td>
<td>reject</td>
</tr>
<tr>
<td>$H_{01c}$</td>
<td>There is no statistically significant contribution of multiplication fact fluency in predicting math anxiety.</td>
<td>14.1%</td>
<td>00.0%</td>
<td>fail to reject</td>
</tr>
<tr>
<td>$H_{01d}$</td>
<td>There is no statistically significant contribution of problem solving ability in predicting math anxiety.</td>
<td>16.6%</td>
<td>2.5%</td>
<td>fail to reject</td>
</tr>
<tr>
<td>$H_{01e}$</td>
<td>There is no statistically significant contribution of math confidence in predicting math anxiety.</td>
<td>52.3%</td>
<td>35.7%</td>
<td>reject</td>
</tr>
</tbody>
</table>
The demographic variables did not show to be statistically significant in predicting mathematics anxiety. Problem solving was also found to add no statistically significant contribution to the model. Therefore, the regression equation for this study is $Y = 84.200 + 0.346X_4 + 0.048X_5 + 0.064X_6 - 0.569X_8$.

Table 4.13

*Full Hierarchical Regression Model*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>84.200</td>
<td>16.247</td>
<td>5.183</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.854</td>
<td>1.469</td>
<td>0.033</td>
<td>0.581</td>
<td>0.562</td>
</tr>
<tr>
<td>Race</td>
<td>-0.158</td>
<td>0.704</td>
<td>-0.013</td>
<td>-0.224</td>
<td>0.823</td>
</tr>
<tr>
<td>SES</td>
<td>1.801</td>
<td>1.728</td>
<td>0.062</td>
<td>1.043</td>
<td>0.299</td>
</tr>
<tr>
<td>Grades</td>
<td>0.346</td>
<td>0.137</td>
<td>0.188</td>
<td>2.536</td>
<td>0.012</td>
</tr>
<tr>
<td>GCRCT</td>
<td>-0.048</td>
<td>0.025</td>
<td>-0.187</td>
<td>-1.943</td>
<td>0.054</td>
</tr>
<tr>
<td>Fact Fluency</td>
<td>0.064</td>
<td>0.028</td>
<td>0.147</td>
<td>2.286</td>
<td>0.024</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>-0.200</td>
<td>0.167</td>
<td>-0.107</td>
<td>-1.201</td>
<td>0.232</td>
</tr>
<tr>
<td>Math Confidence</td>
<td>-0.569</td>
<td>0.051</td>
<td>-0.689</td>
<td>-11.109</td>
<td>0.000</td>
</tr>
</tbody>
</table>
CHAPTER FIVE: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Discussion

As our world continues to move toward a global society, mathematics will become an even greater component of successful functioning (Geist, 2010). Unfortunately, mathematics anxiety has been identified as a reason that many people avoid doing mathematics in their careers and everyday lives. Math anxiety is defined as “the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem” (Erden & Akgul, 2010, p. 4). Basic foundations of mathematics begin in the elementary school years. This study sought to determine if mathematics anxiety existed as early as elementary school and what variables could serve as statistically significant predictors of math anxiety. Specifically, the study examined whether multiplication fact fluency, problem solving, and math confidence would have a statistically significant predictive relationship with math anxiety when demographics and prior achievement were controlled.

The design that was chosen for this study was a predictive correlation design. There was no intervention or control group for this study, which meant that the study had to be a non-experimental design (Warner, 2013). Instead, the study examined relationships between variables which made this design the most appropriate choice (Warner, 2013). The analysis that was conducted was hierarchical regression. This analysis was chosen so that previously entered variables could be controlled as each new block of variables was added. This allowed for the data to be examined for changes in the predictive capacity at each level of variable entry.

This study sought to apply the theories of psychosocial development and social learning to students’ feelings of mathematics anxiety. The level of development that Erikson (1950) describes during late elementary school is one in which students experience success or failure
based on their achievement on many different tasks. Many students are experiencing these crises in school, and are either becoming confident or insecure in facing new situations. Students’ lack of prior achievement or success with mathematics may lead them to feelings of incompetence (Jansen et al., 2013). Albert Bandura (1997) developed a similar theory of social learning that defined self-efficacy as an important step in being able to overcome challenging tasks. Self-efficacy is defined as “beliefs in one’s capabilities to organize and execute the courses of action required to produce given attainments” (Bandura, 1997, p. 31). The study examined whether students’ feelings of confidence or anxiety were related to their prior success with mathematics and their current fluency with basic facts.

The sample included 174 fourth graders at two elementary school locations, within the same school district. The study information, along with consent and assent forms, were sent to approximately 330 students. Of those students, 192 students returned their consent forms. Twelve students were excluded from the study because they were new to this state. This meant that they were missing prior achievement scores from state standardized testing. The students still participated, but their scores were excluded from analysis. Also, six students were absent on the day that the self-report surveys were taken at their school. These students were also excluded, leaving the total number of participants at \( N = 174 \).

After receiving conditional Institutional Review Board (IRB) approval, the principals at each research location were contacted to gain permission to use their school for the study. The principals signed a form stating their cooperation with the study that was then submitted to the County Office of Student Assessment, which must approve any type of data collection done within the school system. Once the approval was gained from the County Office of Student Assessment, full IRB approval was granted. Immediately following IRB approval, informational
letters and consent/assent forms were sent home with all fourth grade students. They were given one week to return forms in return for a piece of candy. After forms were returned, each teacher was scheduled a time in which surveys and multiplication fact fluency tests were administered to the class by the researcher. Once this data collection was completed, student information for demographics and prior achievement variables were gathered from school personnel with access to this information. After all data collection was complete the information was entered into version 22 of the Statistical Package for Social Sciences (SPSS) software. Before scores for the math confidence subscale of the ATMI (Attitudes toward Mathematics Inventory) could be entered into the data analysis there were nine questions that needed to be renumbered due to their wording. These nine questions were negatively phrased and needed to be rescaled, while the rest of the scale was negatively phrased. These questions were rescaled before the score for this variable was calculated and entered into SPSS.

Using SPSS, all descriptive statistics were analyzed as well as assumption testing and the examination of the correlation between all variables. The final step in the data analysis was the actual hierarchical regression. This analysis was used to determine the percentage of mathematics anxiety that could be predicted by the model at each level. This study had five individual models, due to the five blocks of variable entry. The fifth and final block was the full model.

Prior research in the area indicated that mathematics anxiety was a great problem among teenagers and adults. This study added to the literature by filling a gap with elementary aged students. The study indicated that students do in fact report feelings of mathematics anxiety. A score of 22 indicated no mathematics anxiety and a score of 88 indicates very high mathematics anxiety. The results of the mathematics anxiety survey (M = 44.09, SD = 12.61) indicate that
students are having feelings of mathematics anxiety as early as fourth grade. This is an interesting finding because it adds to the literature regarding the existence of mathematics anxiety in elementary school children. This sample included 52 students that scored in the range of 50-88 on the mathematics anxiety scale. This is the level at which mathematics anxiety could possibly hinder progress.

The purpose of the study was to examine the statistical significance of the relationships between the predictor and criterion variables. The outcome of the hierarchical regression indicated that Model 1 (demographics) did not have a statistically significant predictive relationship with mathematics anxiety. It was useful in predicting only 3% of the criterion variable. Model 2 (prior achievement) was a statistically significant predictor of mathematics anxiety. It contributed an additional 11.1% to the overall model. Model 3, which added multiplication fact fluency was not statistically significant and did not contribute anything additional to the model. Model 4 added problem solving ability to the overall model. This was determined to be statistically significant and accounted for a total of 16.6% of the prediction of mathematics anxiety. Finally, model 5 which included all of the predictor variables and added math confidence accounted for 52.3% of the variance in mathematics anxiety. The results of math confidence indicated a high negative correlation between math confidence and math anxiety. Students with high math anxiety indicated low mathematics confidence. This overall model was found to be significant.

**Conclusions**

Each of the variables for this study was included because of prior research or theoretical considerations. Each model entered a new variable and was examined to see how this research aligned with prior research and theoretical connections.
Model one included the demographic variables for this study. The null hypothesis for model one was “There is no statistically significant contribution of demographic variables in predicting math anxiety.” The demographic variables that were included were gender, race/ethnicity, and socioeconomic status. Prior studies in math anxiety have shown that gender is a variable in mathematics anxiety (Ma & Xu, 2004). Many parents, teachers, and even students have seemed to accept that girls are weaker in mathematics than boys (Frenzel & Geotz, 2007). This study indicated that there was a small correlation between gender and mathematics anxiety, $r = .166$. The race/ethnicity variable was included because research has indicated that students coming from minority groups have a great possibility of struggle with mathematics. This may be due to their own prior achievement, the educational background of their parents, and language barriers (Wei et al., 2013). There have been studies that indicate Hispanic students encounter mathematics deficits that grow over time, while other minority students enter school already having mathematics deficits (Wei et al., 2013). There was no indication of a correlation between race/ethnicity and mathematics anxiety. However, there was a correlation between race/ethnicity and prior achievement variables. The socioeconomic status variable was an important one because of the possibility of students with low socioeconomic status having barriers to overcome that are not aligned with their cognitive ability (Geist, 2010). The examples seen from parents, that often include negative attitudes toward mathematics, may impact students from this type of environment (Furner & Duffy, 2002; Geist, 2010). Negative attitudes inhibit the confidence of students and lead them to believe they will never be successful (Kesici et al., 2010). Mathematics anxiety and SES had no significant correlation. However, there was a small correlation with the GCRCT prior achievement variable. The overall Model 1 was not
significant in predicting mathematics anxiety, which lead to the failure to reject this null hypothesis.

Model two of the analysis added the prior achievement variables. The null hypothesis for this model was “There is no statistically significant contribution of prior achievement in predicting mathematics anxiety.” Prior achievement was included because there has been a great deal of research regarding the relationship between math anxiety and math performance (Akin & Kurbanoglu, 2011; Devine et al., 2012; Jansen et al., 2013). There is typically a negative correlation between mathematics performance and math anxiety (Akin & Kurbanoglu, 2011). The results of this study indicated that there was a negative correlation between both prior achievement variables. GCRCT and mathematics anxiety had a correlation of $r = -.354$, and prior grade average had a small correlation ($r = -.194$) with math anxiety. This indicates that students with low prior achievement do in fact have higher levels of mathematics anxiety. The correlation of these variables demonstrates a relationship between prior achievement and math anxiety. However, it does not indicate whether achievement impacts math anxiety or math anxiety influences level of achievement. This is also a possibility that other variables are impacting both math anxiety and prior achievement. This model showed significance and therefore the null hypothesis was rejected.

Model three added the multiplication fact fluency variable. The null hypothesis for this model was “There is no statistically significant contribution of multiplication fact fluency in predicting mathematics anxiety.” This variable was added to apply the theories of information processing and psychosocial development. Research has indicated the fluency in basic math facts is one of the most fundamental skills for participation in higher level mathematics (McCallum & Schmitt, 2011). There was a very small negative correlation ($r = .151$) between
multiplication fact fluency and mathematics anxiety. However, this model did not add any contribution to predicting math anxiety and therefore resulted in failure to reject the null hypothesis.

Model four in the analysis added problem solving ability. The null hypothesis was “There is no statistically significant contribution of problem solving in predicting mathematics anxiety.” The results of this study indicated that there was a medium negative correlation, $r = -.354$, between mathematics anxiety and problem solving. This indicates that students’ ability to work through grade level problem solving will lead to a lower level of mathematics anxiety. This model was statistically significant and added to the prediction of mathematics anxiety. Therefore, it resulted in the failure to reject the null hypothesis for Model four.

Model five was the final model, which included all of the variables for the study. The variable that was newly added in this block was math confidence. The null hypothesis for this model was “There is no statistically significant contribution of math confidence in predicting mathematics anxiety.” Math confidence is the way students feel about how they will perform and this has shown to impact achievement (Ahmed et al., 2011). Prior research has indicated that there is a predictive relationship between mathematics anxiety and math confidence (Ahmed et al., 2011). Some actually view poor self-confidence in mathematics as the cause for mathematics anxiety (Ahmed et al., 2011). In this study, mathematics anxiety and math confidence had a high negative correlation ($r = -.691$). This indicated that students with low math confidence had high math anxiety and those with high confidence had low levels of anxiety. This model was also significant, which lead to failure to reject the null hypothesis. This indicated that the overall model was significant. The addition of math confidence added to the
ability to predict mathematics anxiety. The final model added all predictor variables and was able to predict mathematics anxiety in fourth grade students at a statistically significant level.

**Implications**

The results of this study indicate that there is a population of students who are beginning to suffer mathematics anxiety as early as fourth grade. This holds great significance for educators because students with mathematics anxiety may not be able to perform to their cognitive ability. Research in mathematics achievement across the world has indicated that the United States has been ineffective in the teaching of math (Ashcraft & Krause, 2007). Students are mastering grade level content at a very inferior rate (Ashcraft & Krause, 2007) and low proficiencies are consistently recorded in achievement scores for the United States (Glover et al., 2010). The current workforce requires a great deal of mathematics and science knowledge and those who have not mastered skills will not be able to effectively participate (Ashcraft & Krause, 2007). If mathematics anxiety is noted as a problem for students, it must be addressed as any other achievement obstacle. Possibilities for educators include the early identification of those with mathematics anxiety and the use of interventions to alleviate these feelings. Educators may need to target specific populations of students, or even administer a universal screening for this problem. Possibilities include counseling and the use of positive and encouraging comments in the classroom. The fact that some students have reported feelings of panic with regards to mathematics (Ravi & Manju, 2013), makes this a very serious problem that must be considered if changes in mathematics achievement are going to happen at the onset of students’ interactions with mathematics.

Current and future teachers should be seeking out alternatives to the current curriculum that may limit the development of mathematics anxiety (Geist, 2010). These curricular
alternatives include no timed tests or speed drills that may cause anxiety. Another way to combat mathematics anxiety is to avoid the use of textbooks that encourage students to practice and memorize procedures for which they have no conceptual understanding (Geist, 2010). Teachers should give students as many opportunities as possible to develop conceptual understanding through discovery-based learning. This non-threatening type of curriculum is more aligned with the developmental appropriateness for elementary students.

A mathematics anxiety study that included students at international schools in Bangkok, discovered that students do in fact suffer from mathematics anxiety (Shaikh, 2013). The study listed several recommendations for these students that could be used with elementary school students in the United States. First, the study found that students suffering with mathematics anxiety have a general lack of basic knowledge. Therefore, it is important that basic knowledge is retaught until it is mastered. This basic knowledge included terminology, operations, and basic problem solving processes. It is also important to included parents in the process of overcoming mathematics anxiety. Students suffering with mathematics anxiety may follow the lead of their parents and teachers. This means that parents and teachers must take a proactive role in the positive attitude development of students toward mathematics (Shaikh, 2013). This included taking time to talk to students about their feelings, trying to identify when negative feelings and anxiety began, and proactively working to change these attitudes (Shaikh, 2013).

Another suggestion for combatting mathematics anxiety was the use of peers and building a sense of community in mathematics (Shaikh, 2013). Peer tutors and group projects help students to learn in a non-threatening way. Students may also find that others have the same feelings as they do when they are encouraged to talk with peers about how they feel when completing mathematical tasks. Finally, students can learn relaxation techniques to help combat
their feelings of mathematics anxiety (Shaikh, 2013). It is beneficial for teachers to understand what type of emotional and physical characteristics are causing the mathematics anxiety and use relaxation techniques to prevent these from interfering with mathematical processing (Shaikh, 2013).

**Limitations**

Omitted variable bias is one of the limitations that was considered for this study. In order to ensure that the predictive model is as accurate as possible, all possible predictors need to be included in the model. In the future, as mathematics anxiety is studied further with children, additional variables may be determined to be important and significant to the model. At this point, it is believed that all known predictors of mathematics anxiety were included to control for omitted variable bias.

Another limitation of the study is the research design itself. When conducting a predictive correlation study, there is no ability to infer causality. Therefore, the study can only examine relationships, but not explain any causes.

The nature of the surveys that were administered may be a limitation of the study. Students were asked to complete two different self-report surveys. This may be a difficult task for young students. They may feel that there is a right and wrong answer, no matter how their confidentiality is guaranteed. Young students may also have a difficult time accurately rating their feelings on a scale.

This study was also done with students in similar schools within the same school district. The study was done with only students who returned consent and assent forms and may have left out a large portion of the population that would have been beneficial to include in the study.
Many of the students who did not return consent forms were lower achieving students and did not want to participate. This may limit the ability to generalize the findings to other populations.

**Recommendations for Future Research**

This study leaves the possibility for future research with mathematics anxiety, including both elementary students and older students. One possibility for future research would be a study with the same design but an older population, such as middle school. This may lead to more accurate reporting for the mathematics anxiety and math confidence surveys. Also, it is possible that poor fact fluency becomes a greater inhibitor to success as students get into more difficult mathematics. This could possibly lead to higher levels of mathematics anxiety. It is likely that older students could identify these feelings more accurately. Therefore, a replication study with an older population could be done.

Another possibility would be a quasi-experimental design. The inclusion of an intervention for math confidence and math anxiety, with a control group, could show how feelings of apprehension toward mathematics can be changed. This would also allow for a causal relationship, which is not possible with the non-experimental design of the current study.

**Summary**

This research study examined the predictive relationship between multiplication fact fluency, problem solving, math confidence, and mathematics anxiety, while controlling for demographic and prior achievement variables. This study was distinctive because of its inclusion of young elementary-aged students. The results indicated the multiplication fact fluency was not a significant predictor of mathematics anxiety, when other variables are controlled. The most significant predictor of mathematics anxiety was mathematics confidence which is a separate construct. These two variables had a very strong negative correlation. The
existence of mathematics anxiety in elementary school students is confirmed and should be examined by future research and practitioners.
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APPENDIX A

Math Anxiety Scale for Children

http://eric.ed.gov/?id=EJ426832
APPENDIX B

Attitudes toward Mathematics Inventory (ATMI)- Math Confidence Subscale

http://link.springer.com/article/10.1007%2Fs10649-012-9414-x
APPENDIX C

Sample from Fact Fluency Probe

\[
\begin{array}{cccccccc}
4 & 8 & 9 & 12 & 3 & 1 & 10 \\
\times 3 & \times 8 & \times 7 & \times 2 & \times 6 & \times 1 & \times 2 \\
\hline \\
2 & 1 & 9 & 0 & 0 & 9 & 6 \\
\times 7 & \times 8 & \times 2 & \times 5 & \times 3 & \times 1 & \times 4 \\
\hline \\
9 & 7 & 4 & 10 & 10 & 6 & 9 \\
\times 9 & \times 8 & \times 9 & \times 6 & \times 4 & \times 0 & \times 5 \\
\end{array}
\]
APPENDIX D

Institutional Review Board Approval Letter

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

August 13, 2014

Julie Dutko
IRB Approval 1927.081314: Understanding Mathematics Anxiety: The Relationships between Fourth-Grade Students' Math Anxiety, Multiplication Fact Fluency, and Problem-Solving Ability

Dear Julie,

We are pleased to inform you that your above study has been approved by the Liberty IRB. This approval is extended to you for one year from the date provided above with your protocol number. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Please retain this letter for your records. Also, if you are conducting research as part of the requirements for a master’s thesis or doctoral dissertation, this approval letter should be included as an appendix to your completed thesis or dissertation.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

[Name Redacted]
Fernando Garzon, Psy.D.
Professor, IRB Chair
Counseling

Liberty University | Training Champions for Christ since 1971
APPENDIX E

Written Approval from Participating School District

Cherokee County School District

August 11, 2014

Dr. Garzon,

Please let this letter serve as verification that Julie Dutko has been granted permission to conduct research within Cherokee County School District. Specifically, permission to recruit students, conduct research, and collect archived data has been approved for this study. Ms. Dutko’s research has been approved for [Redacted] and [Redacted] both a part of Cherokee County Schools.

Sincerely,

[Redacted]

Gayle McLaurin, Ed.D.
Director of Student Assessment
Cherokee County School District
APPENDIX F

Approval Signatures from School Administrators

CHEROKEE COUNTY SCHOOL SYSTEM
REQUEST FOR PERMISSION TO CONDUCT DATA COLLECTION ACTIVITIES WITHIN THE SYSTEM

Julie Dutko

Name

CCSD Employee: Yes ___ No ___ If NO, list employer: ____________________________

College/University Supervising Activities

Liberty University

Degree in Progress(Land/Area)

Doctorate/Curriculum & Instruction

Locations for Data Collection

__________________________

Date of Request 8/4/14 Requested Date(s) for Data Collection Sept. 2014

Professor's Name Dr. Nathan Putney Phone #/Email ____________________________

Include with this request:

➢ A letter from your supervising professor on college or university letterhead indicating support for your research and his/her confirmation of data collection validity.

➢ A brief summary of the issues being researched and the type of data collection you are requesting to conduct. (Page 2 of this form).

➢ Method of data collection assessment (Page 2 of this form); Number of respondents, etc.

➢ Copy of interview questions, surveys, etc. that will be used. If student data/videos are used, a notarized "Release of Educational Records for Research Purposes Confidentiality Statement" and a copy of a letter requesting parent permission to use the data will be required.

Julie Dutko do hereby submit to not hold the Cherokee County School System liable for any findings, or commentary involved in this research. I understand that without the express written permission of the Cherokee County Board of Education, I am not authorized to conduct any data collection involving system employees or students and/or any other information that is protected by Federal or State Law. Furthermore, a copy of all findings and data collection instruments will be made available to the Cherokee County Board of Education. All research is to be sent to the Office of Assessment upon completion of the project.

Signature ____________________________ Date 8/1/14

Signature of Principal (if applicable) ____________________________ Date 8/1/14

Send completed form to: Dr. Gayle McLaurin, Director, Office of Assessment, ESA, Building G

Staff Use Only

Permission given  Permission denied

Office of Assessment

Conditions of Permission: Denied due to:
APPENDIX G

PARENTAL CONSENT FORM

Understanding mathematics anxiety: The relationships between fourth grade students' math anxiety, multiplication fact fluency, and problem solving ability.

Julie Dutko
Liberty University
Education Department

Dear Parents,

Your child is invited to be in a research study of math anxiety in elementary students. Your child has been selected as a possible participant because the study focuses specifically on fourth grade students. I ask that you read this form and ask any questions you may have before agreeing to be in the study.

Julie Dutko, a doctoral candidate in the education department at Liberty University, is conducting this study.

Background Information:
The purpose of this study is to determine if math anxiety exists in fourth grade students. The study will also examine the existence of a predictive relationship between students’ multiplication fact fluency, prior achievement, and demographic information with the math anxiety.

Procedures:
If you agree to allow your child to be in this study, I will ask the student to do the following things:

Risks and Benefits of being in the Study:
The risks involved in this study are no more than what the child would encounter in everyday life. There are also no immediate tangible benefits for students participating in this study. However, the study could lead to the identification of mathematics anxiety and its possible predictors in the elementary setting. This could help educators understand how students feel about mathematics and give them the appropriate resources to manage these feelings before the problem progresses. The possible benefits may also include curriculum changes to minimize any possible predictors of math anxiety.

Compensation:
Students will not receive any financial payment for their participation in the study. Any student that returns their assent and consent forms will receive candy from their teacher, regardless of their decision about participation.
Confidentiality:
The records of this study will be kept in a secure, locked cabinet. Research records will be stored securely and only the researcher will have access to the records. The information will be included in a doctoral dissertation and possibly a published report in the future, but will not include any information that will make it possible to identify a subject. After three years, the data collected for this study will be disposed of by shredding all data.

Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect your current or future relations with Cherokee County Schools or Liberty University. If you consent to your child’s participation, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:
The researcher conducting this study is Julie Dutko. You may ask any questions you have now. If you have questions later, you are encouraged to contact her at [contact information]. If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, you are encouraged to contact the Institutional Review Board or email at [contact information].

Please notify the researcher if you would like a copy of this information to keep for your records.

Statement of Consent:
I have read and understood the above information. I have asked questions and have received answers. I consent to my child’s participation in the study.

(Note: Do not agree to participate unless IRB approval information with current dates has been added to this document.)

Student Name: __________________________________________________________

Signature of parent or guardian: ______________________________ Date: _____________
(If minors are involved)

Signature of Investigator: ______________________________ Date: _______________
APPENDIX H

Assent of Child to Participate in a Research Study

What is the name of the study and who is doing the study?
The name of this study is: Understanding mathematics anxiety: The relationships between fourth grade students' math anxiety, multiplication fact fluency, and problem solving ability. The study is being done by Julie Dutko.

Why are we doing this study?
We are doing this study to find out if multiplication fact fluency is related to the way students feel about math.

Why are we asking you to be in this study?
You are being asked to be in this research study because we are very interested in how fourth grade students feel about math.

If you agree, what will happen?
If you agree to be in this study, you will answer questions about how math makes you feel. You will also be given two minutes to see how many basic multiplication facts you can answer.

Do you have to be in this study?
No, you do not have to be in this study. If you want to be in this study, then tell the researcher. If you don't want to, it's OK to say no. The researcher will not be angry. You can say yes now and change your mind later. It's up to you.

Do you have any questions?
You can ask questions any time. You can ask now. You can ask later. You can talk to the researcher. If you do not understand something, please ask the researcher to explain it to you again.

Signing your name below means that you want to be in the study.

Signature of Child ___________________________ Date____________________

Julie Dutko

Dr. Nathan Putney
APPENDIX I

Script for Administration of the Math Anxiety Scale for Children (MASC)

The italicized script below will be read verbatim to students.

“Students: Thank you for your willingness to participate in this study. I hope that, with your help, I will be able to understand how you are feeling about math at school and in your everyday life. Today we will be taking the Math Anxiety Scale for Children to help better understand your feelings about math. The survey will consist of 22 situations that you might experience with math. You will need to rate how these situations make you feel. There are four choices: not nervous (1), a little nervous (2), very nervous (3), or extremely nervous (4). Please know that your answers are confidential and will not be shared with anyone, including your teacher. It is important that you answer as honestly as possible. Please begin by writing your student identification number at the top of the survey, where it says Student ID. As I read each statement to you, please indicate from 1-4 how that situation makes you feel. Are there any questions about the survey or how to mark your answers?”

Each question will be read aloud to students. Papers will be collected upon completion and checked to make sure all questions have been answered and ID numbers have been recorded, in order to link data.
APPENDIX J

Script for Administration of the Attitudes toward Math Inventory (ATMI)

The italicized script below will be read verbatim to students for the ATMI.

“Students: We will also be taking Attitudes toward Math Inventory to better understand your feelings about and experiences with math. This survey will consist of 15 statements about mathematics. You will need to rate these statements on a scale of 1-5. If you choose 5, that means that you strongly agree with the statement, and selecting 4 means you somewhat agree with the statement. Choosing 3 indicates that you neither agree nor disagree with the statement. Choosing 2 indicates that you somewhat disagree with the statement, and a choice of 1 indicates a strong disagreement with the statement that has been read. Please know that your answers are confidential and will not be shared with anyone, including your teacher. It is important that you answer as honestly as possible. Please begin by writing your student identification number at the top of the survey, where it says Student ID. As I read each statement to you, please indicate your level of agreement or disagreement from 1-5. Are there any questions about the survey or how to mark your answers?”

Each question will be read aloud to students. Papers will be collected upon completion and checked to make sure all questions have been answered and ID numbers have been recorded, in order to link data.
APPENDIX K

Script for Administration of the Multiplication Fact Fluency Probe

The italicized script below will be read verbatim to students.

“Students: The final portion of your participation as the student will be a very brief multiplication facts quiz. You will have exactly two minutes to answer as many multiplication questions as you can. Please try to work as quickly as you can and do not stop until the two minutes has expired. This quiz will not impact your grade and is simply used for my information. Are there any questions about what to do on this quiz? Please begin by writing your student ID number at the top of the page. Please only start and stop the quiz when you have been directed to do so. Does anybody need more time to write their ID number? Okay, you may begin.”

Students will be timed for exactly two minutes on a winding down timer. When the time is up students will be asked directly to put their pencils down. All quizzes will be checked to ensure that ID numbers have been recorded, in order to link data.