DISSERTATION

THE RELATIONSHIP BETWEEN MATH ANXIETY AND STUDENT ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS

Submitted by

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ABSTRACT

THE RELATIONSHIP BETWEEN MATH ANXIETY AND STUDENT ACHIEVEMENT OF MIDDLE SCHOOL STUDENTS

A 12-item Math Questionnaire (MQ) was developed and distributed to 381 middle school students in a northern Colorado middle school during the 2013-2014 school year. Data from the Transitional Colorado Assessment Program (TCAP) during the 2012-2013 school year were used to compare mathematics achievement to mathematic anxiety. Middle school grades consist of sixth, seventh, and eighth grade students who range in ages of 11 to 14 years old.

Results from the quantitative study showed there were statistically significant differences between mathematics anxiety and achievement on TCAP. Students who have high mathematics anxiety tend to have low mathematics achievement. Other results showed that sixth grade students had less mathematics anxiety than seventh grade students. Sixth grade students had less mathematics anxiety compared to eighth grade students. Seventh grade students had a higher level of mathematics anxiety compared to eighth grade students. Lastly, results showed sixth grade students had the highest mathematics achievement across the middle school grades. Eighth grade students showed the lowest mathematics achievement compared to sixth and seventh grade.

Overcoming mathematics anxiety is a recipe for success in helping students achieve and grow in mathematics. By understanding, recognizing, controlling, and coping with our mathematical anxiety, students can go further in mathematics than ever before (Boaler, 2008;

Tobias, 1993). A number of recommendations for further research and implications for action are provided in chapter five of this study.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Background and Setting

When a boxer's corner man throws a white towel into the ring, the defeated boxer surrenders. The beating must end and the boxer will be able to fight another day without major injury. Most people understand the reference of tossing a white towel onto the floor as a sign of giving up. Whether out of frustration or lack of self-confidence, the white towel is a symbol of giving up and defeat. Frustration in mathematics often results in a similar outcome. "Seventy-five percent of Americans stop studying math before they have completed the educational requirements for their career or job" (Scarpello, 2007, p. 34). Scarpello indicated many Americans are throwing in the "white towel" when it comes to understanding numbers.

"Math anxiety is commonly defined as a feeling of tension, apprehension, or fear that interferes with math performance" (Ashcraft, 2002, p.181). Those powerful feelings begin at different stages in a child's educational journey. "Math anxiety can begin as early as the fourth grade and peaks in middle school and high school. It can be caused by past classroom experiences, parental influences, and remembering poor past math performance" (Scarpello, 2007, p.34). According to Scarpello, high school students' career options are often determined by the number of math classes they complete. If a student does not take algebra in high school, then access to higher level math classes is not an option. The result is that high school students graduate with a lack of confidence in math and may feel uneasy when doing simple mathematical tasks.

Even as an adult, reading through a typical middle school word problem can trigger an instant reaction of fear or negativity. "If train A left the Fort Collins train station going 50 mph at 7:30 a.m. and train B left the Denver train station going 65 mph at 8:00 a.m., what time will

train A and train B collide if they were 110 miles apart traveling on the same track?" For certain individuals, somewhere along their mathematical journey, math anxiety took over their ability to solve the problem. At one time numbers made sense. Understanding patterns and solving problems used to be fun and uncomplicated, but math anxious individuals begin to avoid all types of math and mathematical thinking. They become frustrated during discussions about numbers and have low self-efficacy about math. Getting to the crux of the problem early is imperative to help students of the 21st century open doors of opportunity instead of closing them.

The research questions identified for this study are focused on students in sixth, seventh, and eighth grade. At the research site, students enter math classrooms with different mathematical abilities and levels of success. Teachers analyze student Transitional Colorado Assessment Program (TCAP) data to identify the level of support needed by each student. The overall proficient and advanced rating scale at the researcher's middle school in mathematics, according to the TCAP results, was 68.2%, which means that 31.8% of students are entering the classroom unsatisfactory or partially proficient on Colorado Common Core State Standards.

This Northern Colorado middle school was chosen for the study because the researcher was the principal of the school. More importantly, the principal was looking for ways to increase student academic achievement and growth in mathematics. Secondly, Scapello (2007) suggested that math anxiety peaks in middle school and by 10th grade students stop taking math. Examining the middle school years is critical for several reasons. One is to pinpoint when a child's math anxiety levels becomes too overpowering and interferes with achievement. Second is to intervene early in a student's mathematical succession, at the point when concepts become more complex. This explains why a middle school is being targeted for the study instead of an elementary school or a high school.

History

Mathematics Anxiety has been a research topic for several decades. Past work of Gough (1954) and Dreger and Aiken (1957) noted that mathematical performance is influenced by nonintellectual factors. Gough (1954) defined Mathemaphobia as a fear in the presence of mathematics that creates a negative attitude. Dreger and Aiken (1957) investigated the idea that math attitude scores made a significantly predict achievement in mathematics. Richardson and Suinn (1972) created a 98-item Mathematics Anxiety Rating Scale (MARS), which is the most used instrument to measure math anxiety. Suinn, Edie, Nicoletti, and Spinelli (1972) used the MARS in a study to measure math anxiety in students. Wigfield and Meece (1988) used a Student Attitude Questionnaire (SAQ) with students in 6th through 12th grade. The questionnaire in their study assessed the levels of math anxiety and student's beliefs concerning mathematics. Hembree (1990) studied the nature, effects, and relief of mathematics anxiety concluding that mathematics anxiety depresses performance.

Rationale for Study

Math is part of our daily lives. Understanding how a car functions or interacting with fractions while making a favorite recipe involves math, yet Tobias, (1993) stated "people who don't know what math is don't know what math isn't. Therefore, fear of math may lead them to avoid all manner of data and to feel uncomfortable working with things" (p. 33).

The researcher had several motivations to examine math anxiety. Recently, reports have surfaced about the performance of American students compared to foreign students in the area of mathematics and science. According to the Trends in International Mathematics and Science Study (TIMSS) 2003, 2007, 2011, United States eighth grade students scored a 7% in the advanced international benchmark and 30% in the high international benchmark, ranking them

10th. Chinese Taipei, Singapore, Korea, Hong Kong, and Japan all had higher international benchmark ratings than the United States. Exploring math anxiety further may shed some light on the reasons American students are scoring lower.

Another rationale for this study was to explore math anxiety as a barrier of mathematical achievement. Furner and Gonzalez-Dehass (2011) explained that "math anxiety is a real issue that can impact a young person's goals, many career-related decisions they may make in life and their overall future" (p.227). Meece, Wigfield, and Eccles (1990) added that strong mathematical backgrounds are critical for many careers in our every demanding technical society. Our changing world is becoming more economically competitive and doors of opportunity are closing for students who struggle in mathematics. Occupations that require analytical thinking and math skills become unattainable as fearful students rule out higher level math courses. The national movement of increasing the numbers of students entering science, technology, engineering, and math (STEM) related career fields is critical. Sharpe (2012) reported about 43% of employers report a problem recruiting staff with the right STEM skills. Reasons for not attaining STEM type skills is explained by Bekdemir (2010), who believed many events in a person's life determine the mindset of thinking negatively about mathematics. Geist (2010) stated that math anxiety and negative attitudes towards mathematics are serious obstacles for children in all levels of schooling. This negative attitude toward mathematics is creating a disparity between levels of mathematics achievement.

Helping middle school students understand the effects of mathematics anxiety is critical. With increased demand for people in STEM fields, it is evident schools need to focus on young people's understanding mathematics at a level that enables students to enter STEM career fields. Jobs of the future will be related to having an understanding of mathematical thinking and the

United States has a global responsibility to produce more of a workforce with an expertise in the math, science, and technology field.

Boaler (2008) shared her experience at Stanford University where over the past 10 years 16 out of 1,470 students were math majors. This low number of math majors has created a sense of urgency for researchers to understand the disparity between non math majors and math majors. "Achievement and interest among children is low, but the problem does not stop there. Mathematics is widely hated among adults because of their school experiences, and most adults avoid mathematics at all cost" (Boaler, 2008, p .4). She continues to explain that adults need to think more mathematically to survive in today's society.

Purpose of the Study

Math anxiety is detrimental to success in mathematics. "An obvious but unfortunate consequence of the avoidance tendency is that compared with people who do not have math anxiety, highly math-anxious individuals end up with lower math competence and achievement" (Ashcraft, 2002, p. 182). Ashcraft explained that individuals with a high level of math anxiety take fewer math courses compared to individuals with low math anxiety; individuals with a high level of math anxiety avoid important career paths that require mathematical thinking. With that research in mind, the first purpose of this study was to look at math anxiety and how it affects student achievement of sixth, seventh, and eighth grade students attending the researcher's middle school in Colorado. The second purpose was to better understand the issues related to math anxiety so policies and strategies can be implemented to reduce math anxiety.

Research Questions

With a focus on math anxiety in the middle school, the following research questions examined how a student's math anxiety scale score correlated to student achievement as measured by the TCAP.

1. What is the association between mathematics anxiety and achievement on TCAP in mathematics?
2. Do high mathematics anxiety middle school students and low mathematics anxiety middle school students differ significantly on mathematics achievement as measured by TCAP?
3. Are there differences among sixth grade, seventh grade, and eighth grade students on mathematics achievement and mathematics anxiety?

Definition of Terms

Acuity - a standardized diagnostic and prediction test given to middle school students to predict achievement on the state assessment.

Mathematics anxiety - "A feeling of tension, apprehension, or fear that interferes with math performance" (Ashcraft, 2002, p. 181).

Math Anxiety Questionnaire (MAQ) - the instrument used to assign a math anxiety scale score.

Mathematics - the study of basic number operations and its relationships.

Students - the participants in the study that are members of a middle school environment of sixth, seventh, and eighth grades.

Student achievement - the level of a student's performance on the Transitional Colorado Assessment Program (TCAP) given during the month April. The four scoring categories are Advanced, Proficient, Partially Proficient, and Unsatisfactory.

Trends in International Mathematics and Science Study (TIMSS) - an international comparative study of educational achievement in a number of curriculum areas, including mathematics and science in fourth and eighth grade.

Transitional Colorado Assessment Program (TCAP) - the state assessment program in Colorado formerly known as Colorado Student Assessment Program (CSAP). Sixth and seventh graders take six, 60-minute standardized tests in Reading/Writing and three 65-minute standardized tests in Mathematics. Eighth graders take six 60-minute standardized tests in Reading/Writing, three 65-minute standardized tests in Mathematics, and three 65-minute tests in Science. TCAP testing measures a student's current grade level ability on state standards.

Significance of the Study

In education, there are endless conversations about rigorous curriculum, instruction, and assessments, yet it is not common practice for the public school system to have conversations about the emotional state students are in when trying to learn a specific subject. Researchers point out the importance of continuing the research in math anxiety. As stated by Lou, Wang, and Lou (2009), "Middle school students in our country face much pressure in mathematics learning which, to some extent, leads to students' mathematics anxiety" (p.13).

"Math anxiety is a real issue that can impact a young person's goals, many career-related decisions they may make in life and their overall future" (Furner & Gonzales-DeHass, 2011, p. 227). This study will add to the ongoing research around math anxiety and the effect it has on

student achievement. The instrument used in this study may help educators prescribe an early intervention for those math-anxious students. Classroom teachers, schools, and districts, will be able to monitor a student's math anxiety during middle school.

Delimitations

This study was delimited to students in sixth, seventh, and eighth grade in the Thompson School District located in Northern Colorado. The district serves more than 14,000 students at the time of the study. The Thompson School District is made up of small urban and rural schools. Thompson School District was selected for the study because the researcher was a former middle school principal in the district. Students during the 2013-2014 academic school year participated in the study. A total of 460 students participated: 138 sixth graders, 133 seventh graders, and 189 eighth graders. All students were given the Math Anxiety Questionnaire during the spring of 2014 school year. Previous Transitional Colorado Assessment Program was used. The middle school being used in this study only has two elementary feeder schools.

Limitations

The sample used was from one middle school in the Thompson School District, thus limiting generalizability of the study. There was no control over the schools demographics and each student participating in the study was categorized by current grade level and not by age. Students absent on the day the questionnaire was administered, completed the questionnaire on the next day they were present at school.

Researcher's Perspective

After spending four years in the United States Air Force from 1990-1994, I decided to make a difference with my life by majoring in education. I started off at Glendale Community

College and then was accepted into the teaching program at Arizona State University (ASU). Upon graduation from ASU, I was hired to teach mathematics first at a charter school in south Phoenix then at a public K-8 school in the Deer Valley Unified School District. After three years in Arizona, I relocated to Fort Collins, Colorado in 2001 with my wife and two-year old son to continue teaching. I was an eighth grade mathematics teacher in Loveland, Colorado, for three years before transferring into the dean of students position at the same middle school. This is my 11th year as an administrator and decided to focus my dissertation on the subject of mathematics instead of exploring a leadership topic.

Education is at a crossroads where understanding your content and building relationships with students is not the only thing important in the classroom. Senate Bill 191, Educator Effectiveness, evaluates educators on the achievement and academic growth of students in reading, writing, math, and science. Fifty percent of a teacher's evaluation is focused on the academic growth and achievement of students, while the other 50% centers on the Colorado Teacher Quality Standards. The building principal is partly evaluated on the percentage of teachers rated effective or highly effective on their evaluation. This is a game changer for educators in a profession that is rapidly changing. No longer will teachers hold a tenure status, but rather hold an ineffective or effective status that is portable within the state of Colorado.

The research in this study will help me identify possible barriers standing in the way of all students learning mathematics. While teaching, I took immense pride knowing my students had a better understanding of mathematics when they exited my classroom. Students who expressed a fear of math at the beginning of the school year left with an improved confidence in math. Over the years, wanting to help students improve their self-confidence in mathematics became a focus point. As a teacher, math curriculum coordinator, math coach, and a curriculum

trainer, I became disappointed in the educational system and its lack of urgency to identify nonintellectual factors such as math anxiety as an obstacle for student learning. This system was producing students who were unsuccessful in math.

Through on-going discussion with unsuccessful math students, I noticed students using words similar to those researchers defined as math anxiety. Words such as hate, fear, anxious, and nervous were used by my students. Each year a percentage of students would enter my classroom with the heavy weight of low test scores, hating math, and no desire to become successful with content standards; other students entered my classroom loving math, having high test scores, and craving the content standards.

Year-in and year-out, math teachers throughout our building were forced to focus on standard based learning and data gaps as a way to guide instructional practices. Not once did we explore anything outside the curriculum like math anxiety as a reason for these academic gaps. We would spend endless hours talking about how to teach mathematical concepts. A few of us even explored the Japanese Lesson Study model through the Colorado Department of Education (CDE). All those hours never showed any statistical significance on improving test scores. Our scores were flat and even at times showed a decline in achievement.

The main responsibility of a building principal is the academic proficiency and academic growth for each and every student enrolled in a public school. The researcher's school was showing a lack of growth in mathematics. They continued to have conversations focused on the results of the data and research-based instructional strategies to help struggling students. The math department did an effective job analyzing data, changing instruction, and even implemented interventions for unsatisfactory students. Not once did the teachers in the math department discuss the possibility of math anxiety being a barrier to math achievement.

Our society has made it acceptable to underachieve in mathematics. Parents never shy away from proclaiming their deficiency in math or how much they loathed math in school. Parents wear their misunderstanding of mathematics as a badge of honor claiming they did not inherent the math "gene" compared to their classmates. I shake my head in disbelief when I hear parents make those comments. Students are our future and how they problem solve and think analytically is important to our very existence. I believe in students and their innate ability to solve mathematical problems. I want to improve a public school system that is viewed as broken, flawed, underachieving, and incapable to compete with other countries. I understand the importance of preparing students to be successful in the STEM disciplines and have the skill to be college ready or ready to enter the workforce. We have a responsibility to prepare students for our future not for our past. Students need to be better prepared in mathematics. Students should view the learning of mathematics as a positive experience and not viewed as being held hostage by a nutty math professor.

Through this research, I examined several questions about math anxiety at the middle school. I hope to begin the conversation at our school and in our school district about the effects math anxiety has on student achievement. If the instrument used in this study identifies the level of math anxiety for a middle school student, then our staff could put an early intervention in place. This information could be vital in helping students become proficient in mathematics, show a year's growth, and continue to build their confidence in math.

Summary

Schools and school districts have been apprehensive to identify factors that have negative influences on student success in mathematics. Middle school students do experience math anxiety and it does influence their mathematical achievement. There is reason to conduct this

study as chapter one discussed the statement of the problem, purpose of the study, and the significance. There are interventions available for students who are below proficiency in mathematics, but not interventions addressing math anxiety. Schools fail to recognize math anxiety as a possible cause for a breakdown in learning mathematics. This study examined and explored math anxiety as a factor for impacting students' achievement in mathematics in the public education system.

CHAPTER 2: LITERATURE REVIEW

Introduction

In the early 1950's, researchers (Dreger and Aiken, 1957; Gough, 1954; Hembree, 1990) suggested that factors of math anxiety were influenced by non-intellectual factors such as math anxiety. Several studies also examined the direct effect math anxiety had on student achievement at the middle school. Ashcraft (2002) described highly math-anxious individuals who avoid math and lower their competency and even ultimately alter their career path. Mathematics anxiety is creating a discrepancy between the proficiency levels in mathematics achievement (Ashcraft, 2002; Geist, 2010; Hembree, 1990; Scarpello, 2007).

As a result of their fears, more and more students are avoiding careers in math related fields. "Individuals with high math anxiety take fewer math courses, earn lower grades in the classes they do take, and demonstrate lower math achievement and aptitude than their counterparts with low math anxiety" (Ashcraft & Kirk, 2001, p. 224). Ashcraft and Kirk (2001) stated before a student is able to feel success in mathematics, they must believe in their ability to understand the subject matter and be able to construct meaning of numbers. These opportunities first take place around adults in the home environment and then progress in the school environment. Either way, the math learning environments need to be supportive and non-threating. Differentiated instruction, manipulatives, math talk, and meta-cognition techniques, are some of the ways to help students learn complex mathematics. Proficiency and mathematical success is the ultimate outcome for students at a time when math is a priority in our society.

Different definitions of math anxiety and the research related to the topic has been explored in this literature review. It examined past studies, gender differences, reasons for math anxiety, and previous instruments used to measure math anxiety.

Mathematical Academic Achievement

Academic achievement in mathematics is a major concern of educational systems across the world. The Organization for Economic Co-operation and Development (OECD) developed the Programme for International Student Assessment (PISA), which compared different educational systems across the globe. PISA evaluated the quality, equity, and efficiency of school systems in 70 different countries. These 70 countries combined make up nine-tenths of the world's economy. "PISA represents a commitment by governments to monitor the outcomes of education systems regularly within an internationally agreed framework and it provides a basis for international collaboration in defining and implementing educational policies" (OECD, 2010, p. 5). PISA focused on an international study of 15 year olds as a means of improving how to help students learn better, teachers teach better, and school systems to become more effective. The 2009 study showed a mathematics mean average score of 496 for the 15 year olds. Korea scored the highest at 546, followed by Finland (541), Switzerland (534), and Japan (529); Krygyzstan scored the lowest with a mean score of 331. The United States had a mean score of 487, which is significantly below the OECD average. The United States also had one of the largest gender differences; boys on average scored 20 points higher than girls.

In mathematics, just like in other content, people have different learning abilities.

> "Learning is a natural and irrepressible activity for the human brain, and we all have the same kind of brain. We won't all achieve the same level of expertise—we differ in general abilities, energy, determination, interest and experience - or will we all learn at the same rate" (Smith, 2002, p. 125).

However, according to Pajares and Miller (1995) and Lou et al. (2009), learning mathematics is about a student's emotional state. Students feeling a high level of anxiety about mathematics will lower their success in the subject.

Anxiety Defined

Peters Mayer (2008) stated, "Anxiety is a mind-body reaction that occurs instantaneously, and its effects are felt physiologically, behaviorally, and psychologically all at the same time" (p. 4). Peters Mayer then defined anxiety as a state of intense agitation, tension, or dread occurring from a perceived threat of danger. The American Psychological Association (2014) defined anxiety as "an emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure." Tyrer (1999) explained that "anxiety covers a range of experience, a large deal of which is normal and experienced by all at some time in their lives, and some of which is pleasurable" (p.1). At the other end of the spectrum, anxiety can become unpleasant and stressful. Anxiety can cause stress, an emotional experience that takes over our mind and body. Tyrer (1999) explained anxiety and its effect on performance:

> As demands increase, anxiety does also, and is rewarded by an improvement in performance. Eventually, however, a plateau of activity is reached in which performance cannot improve anymore. In these circumstances the individual feels tense and anxious and under pressure but is able to cope with this without improving any further in performance. Once anxiety levels increase beyond this point, performance disintegrates rapidly. Concentration deteriorates, the ability to perform coordinated physical and mental activities is lost, and the person ceases to have any control over the task in hand. (Tyrer, 1999, p. 3)

Math Anxiety Defined

Over time, researchers have further defined anxiety specifically in relation to math. Richardson and Suinn (1972) defined mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Latterell (2005) defined math anxiety as "an intense fear of mathematics, and the fear prevents the person from being able to do mathematics" (p. 24). Lou et al. (2009) and Sparks (2011) described math anxiety as a kind of disease or a negative emotional stage created when engaging in activities requiring

mathematical computation. She continued to explain that math anxiety created a discomfort in mathematics and could lead to fewer students pursing math and science careers.

Legg and Locker (2009) defined math anxiety "as a general fear or tension associated with anxiety-provoking situations that involve interaction with math" (p. 471). Their study assessed whether metacognitive skill moderates the effect of math anxiety on performance, reaction time, and confidence on a math task. They further discussed that math anxiety hindered math performance for high achievers and revised a Math Anxiety Rating Scale to assess the level of math anxiety in students.

Concept of Math Anxiety

Wigfield and Meece (1988) highlighted the need for researchers to examine the negative effects math anxiety has on student achievement in mathematics. They found that individuals with high math anxiety showed smaller working memory. Math anxiety affects math related tasks and typically occurs during the classroom instruction whether working on classwork, homework, or in group discussion involving finding solutions to math problems. Understanding the material during class is critical, but taking a math test can trigger even higher levels of math anxiety resulting in a student forgetting everything they learned about a certain mathematical topic. According to Bower (2001),

> "by about age 12, students who feel threatened by mathematics start to avoid math courses, do poorly in the few math classes they do take, and earn low scores on math-achievement tests. Some scientists have theorized that kids having little math aptitude in the first place justifiably dread grappling with numbers." (p. 159)

Ashcraft and Kirk (2001) found substantial evidence that math anxiety affects student performance. They found

> "substantial evidence for performance differences as a function of math anxiety. These differences typically are not observed on the basic whole number facts of simple addition

> or multiplication (e.g., 7 + 9, 6 x 8) but are prominent when somewhat more difficult arithmetic problems are tested." (Ashcraft & Kirk, 2001, p. 224)

Furner and Gonzalez-DeHass (2011) added that mathematics anxiety is not the sole reason for low math achievement but is a "critical academic problem that educators should be informed of its nature as well as of its solutions" (p.231).

In addition to the academic concerns, Ruffins (2007) found math anxiety had psychological symptoms. These symptoms included panicking, a feeling of helplessness, and nervousness before a math class. Speilberger (1995) stated little attention had been given to the emotional and cognitive process of math anxiety. Research on math anxiety has often been directed on the treatment and not on understanding the nature of math anxiety.

Elementary Math Anxiety

Few researchers have explored instruments to determine the levels of mathematics anxiety in elementary students. Baloğlu and Balgalmis (2010) conducted a study that converted the Mathematics Anxiety Rating Scale into an elementary version for Turkish students. The scale was administered to 336 elementary students. The instrument included 26 5-point Likert type items. A total of 104 points were possible with higher scores indicating a higher level of mathematics anxiety. It was concluded that the Turkish MARS-E is a valid and reliable instrument in measuring mathematics anxiety levels at the elementary level. Unfortunately, the math anxiety scores of the elementary students were never published. Sharing the results could have sparked a higher interest in exploring math anxiety levels in students in elementary school.

Adelson and McCoach (2011) conducted a study using the Math and Me Survey to measure elementary students' attitudes towards mathematics. The number of participating students was 437 across 13 different schools, 155 third graders, 238 fourth and fifth graders and 44 sixth graders. Nearly half of the students were female. The survey measured a student's

average enjoyment of mathematics and average mathematical self-perception. A 5-point Likert-type scale was used, with one being the lowest score possible and five being the highest score possible. The average enjoyment of mathematics score was 3.60. The difference in enjoyment of mathematics scores for students one grade level apart was 0.25 ($p < .001$), indicating that younger students enjoy mathematics more than older students. The average mathematical self-perceptions score was 3.70. There was no statistically significance difference in mathematical self-perceptions for students who differed by one grade level ($p = .839$), meaning grade level was not associated with how students perceived themselves mathematically. The important finding from this study was that elementary students still liked math and still perceived themselves as capable of learning mathematics, even while exhibiting low math anxiety.

Ramirez et al. (2013) stated that exploring math anxiety in elementary students was lacking. Results from their study of 91 second-grade students indicated that the "strongest predictor of math anxiety in second-grade children was their level of math self-concept" (p. 518). The environmental factors did not impact math anxiety, however, elementary students with higher levels of math anxiety, had more negative attitudes toward math.

Wigfield and Meece (1988) found that intervention programs "should be implemented during the elementary school years, before children's anxiety about math becomes strongly established" (p. 215). If math anxiety is not addressed at the elementary level, middle school students will continue to become further and further behind in the development of analytical thinking and creating the foundation for number sense.

Middle School / Secondary Math Anxiety

The transition to middle school is challenging and difficult for students. Students enter middle school no longer having one core teacher from start of the day to the end of the day.

Middle school students are expected to learn from different teachers in mathematics, literacy, social studies, science, and certain electives throughout the day. Elias and Bruene Butler (2005) described the adolescent years as being filled with confusion and angst. Adolescents must work through difficult developmental tasks on their way to high school. The middle school years are the battle ground for students to put their thinking skills to the test. Students enter middle schools as concrete thinkers and are expected to leave as abstract thinkers. As these students learn and develop critical thinking skills, their mindset begins to focus on social status instead of academic standing. Peer relationships begin to be more important during the adolescent years (Elias and Bruene Butler, 2005; Tobias, 1993). Those peer relationships truly impact how classmates view someone's interactions inside and outside the classroom. Asking too many questions may be perceived by students as being dumb or incompetent while knowing all the answers come across as being a "smarty pants."

Lou et al. (2009) conducted a study at a university in west China involving 311 students from a middle school. The correlation between mathematics performance and mathematics anxiety was statistically significant negative, and the correlative coefficient was -0.411. The correlative coefficient between the cognitive elements of mathematics anxiety and mathematics performance was -0.339. The results showed the better a student's mathematics performance was, the less mathematics anxiety they experienced. The worse a student's performance was the more mathematics anxiety they exhibited. This confirmed that mathematics anxiety usually happened among low performing students in west China. The participants in this study were only children from middle income families. Although the Lou et al. study contained pertinent and valuable information for the understanding of math anxiety in middle school students, the

study did not involve sixth graders and showed ninth graders having the highest level of math anxiety. The research did not cover the factors leading to math anxiety.

Suinn and Edwards (1982) conducted a study of junior high and senior high students, grades 7 to 11, in Arizona and Colorado. The study focused on identifying students experiencing math anxiety. The study sample was compromised of 497 junior high students from Arizona, 1,020 junior high students were from Colorado, and 290 senior high school students were from Colorado. Only 1,780 samples were used because of incomplete data from the different schools. Two instruments were used, the Mathematics Anxiety Rating Scale and a questionnaire. Students indicated the level of anxiety on a 5-point scale from "not at all" to "very much." The lowest possible score was 98 (low anxiety); a score of 490 indicated a feeling of extreme anxiety. The results from the MARS questionnaire differed. A two-way analysis of variance was computed for the score from each school for the differences in gender. Students with high MARS scores showed lower grade averages in mathematics courses compared to those students with low mathematics anxiety. Boys in the junior high tended to have lower grade averages than the girls. The Colorado junior high schools results were also statistically significant for MARS scores ($F = 40.68$, $p < .001$), but not for gender differences. The study confirmed that high mathematics anxiety, as measured by the MARS, was associated with low mathematics course grades. This study appeared to be a useful diagnostic assessment for identifying students who may need additional help. The only problem with the study was the absence of defining low mathematics course grades. Correlating grades to math anxiety should only be valid if a universal grading scale was used across the different grade levels. At times, grades reflected effort and behavior, not what a student knows or is able to do mathematical.

Further, Birgin et al. (2010) investigated math anxiety among 220 sixth, seventh, and eighth grade Turkish students in terms of mathematics achievement levels, perceived enjoyment of the mathematics teaching method, perceived enjoyment of mathematics, and perceived help with mathematics from parents. A 3×2 factorial ANOVA was computed to test the main effects of grade level and gender on students' mathematics anxiety levels. Results showed that the lowest anxiety was measured among the sixth graders (M=28.32; SD=8.24); the highest anxiety was among the eighth graders (M=33.49; SD=7.57), which showed that mathematics anxiety levels increased as grades level increased. This was similar to Adelson and McCoach (2011) study, which stated students in the lower grades in elementary enjoyed mathematics more than those in the upper grades.

Kesici, and ErdoĞan (2010) studied whether middle school students' mathematics anxiety differed according to their low and high achievement motivation and their level of self-esteem. The study groups were comprised of 156 eighth grade students who attended a private tutoring center in Konya City, Turkey. The quantitative data in this study enabled the researchers to determine whether significant associations between independent variables (achievement motivation and social comparison) and dependent variables (mathematics anxiety) existed. The Mathematics Anxiety Rating Scale developed by Richardson and Suinn (1972) to measure levels of mathematics anxiety was used. The results indicated that social comparisons effect level on mathematics anxiety is large and students with negative self-esteem experience more mathematics anxiety compared to students with positive self-esteem. Secondly, the results showed that mathematics anxiety of students possessing high achievement motivation was significantly higher than those students possessing low achievement motivation.

Wigfield and Meece (1988) conducted a study to assess math anxiety in 6th through 12th grade students. This comprehensive longitudinal study investigated 564 students' beliefs, attitudes, and values concerning mathematics. Year one consisted of 740 middle-class students in 5th through 12th grade. In year two, the sample contained 575 students in grade 6th through 12th. The Math Anxiety Questionnaire (MAQ) was developed prior to this study and was handed out to 250 students in 5th through 11th grade. A 7 x 2 (Grade x Gender) ANOVA was used in the study. On the math worry scale, the grade level main effect was significant, F (6, 555) = 4.01, p < .01 which the mean did not show a consistent pattern. Math worry was highest in 9th grade students (M= 5.46), in 7th, 8th, 10th, 11th, and 12th twelfth grade students (M = approximately 5.00), and 6th grade was (M= 4.63). No gender difference was observed in the worry scale. This study showed that cognitive and affective components of math anxiety can be identified. The researchers recommended that intervention programs to alleviate the negative effects of math anxiety must deal with both affective and cognitive aspects of math anxiety.

Hembree (1990) conducted a meta-analysis to scrutinize the construct mathematics anxiety in 151 studies in grade of sixth to twelfth. Five tasks were defined to explore the nature of mathematics anxiety and the difference between females and males. The results were simple: higher achieving students had less mathematics anxiety and as grade levels increased, so did the level of math anxiety in students. Math anxiety peaked between 9th and 10th grade and started to decrease in 11th and 12th grade. Furthermore, Hembree stated math anxiety was related to poor performance on mathematics achievement tests. In middle school, students experienced different levels of success. High levels of math anxiety appeared in remedial mathematics classes and declined with more advanced classes. Lastly, across all grade levels, female students had a higher level of math anxiety compared to males.

Reasons for Math Anxiety

Math anxiety is a key problem in the educational setting. Ashcraft (2002) expressed that math anxiety interferes with math performance. Students with high levels of math anxiety took fewer math courses in high school and college. Math-anxious students had negative attitudes toward math and possessed negative outlooks on their mathematical aptitude. Ashcraft (2002) expressed that there was no surprise that people with math anxiety avoided career paths depending on math skills. These same students typically sidestepped college majors involving math. Richardson and Suinn (1972) explained that manipulating numbers in a wide variety of ordinary life and solving math problems in the academic setting were reasons for math anxiety. Math anxiety may prevent a student from passing fundamental mathematics courses or prevent the pursuit of advanced courses in mathematics.

Tobias (1993) discussed the fact that math is normally taught in discrete portions by teachers who teach the way they were taught. Students then are tested in the same manner by a summative assessment. Teachers rewarded students for coming up with the correct answer and not for the process of how the problem was solved. The answer is either right or wrong. Instead of embracing attempt as a method, teachers tend to treat errors as shame. This idea of shame resulted in students cringing when they make mistakes. These feelings of apprehension and embarrassment ultimately create a sense of math anxiety. "Eager to avoid errors at all costs, many children never learn how valuable it would be to explore them. Instead, they just sit in the back of the room hoping the teacher will put those flash cards away" (Tobias, 1993, p. 52).

The following sections will examine the parent's role, teacher role, classroom instruction, and student's attitude when it comes to reasons for math anxiety. It will explore reasons for the problem and possible ways to alleviate the problem.

Parent Role

Parents play crucial roles in the education of a child. Whitaker and Hoover-Dempsey (2013) explained that "parents' engagement in their children's learning at home and school offers an important pathway to improved academic and social outcomes for many students" (p. 73). Parents' support of student learning is directly correlated to students exhibiting more of a positive attitude, better attendance, increased positive outlook, higher motivation to learn, and higher test scores. Researchers found that for many children, negative attitudes toward mathematics begin early in life, sometimes even before they enter kindergarten (Arnold, Fisher, Doctoroff, & Dobbs, 2002; Geist 2010). Geist (2010) stated that "before a child can add or even count, they must construct ideas about mathematics that cannot be directly taught" (p. 24). Basic mathematical thinking is constructed even before students enter the classroom. That mathematical construction relies heavily on the interactions within a child's environment and the adults in that environment. Boaler (2005) stated that "one of the very best things that parents can do to develop their children's mathematical interest is to provide mathematical settings and to explore mathematical patterns and ideas with them" (p. 175). Tomlinson and Imbeau (2010) explained that the majority of parents want their children to grow academically by finding the classroom exciting and full of learning. The ultimate goal for parents is to have their student wake up excited about learning and excited about attending school. Unfortunately, on the other hand, we are in a societal shift of parents being quick to judge schools and express those feelings in front of their children. By critiquing the school system, parents are unintentionally modeling an attitude of "its ok" to second guess the teacher or question the principal on curricular decisions.

Girls tend to have more negative math attitudes, higher level of math anxiety, and lower self-concepts than boys (Englehard, 1990; Gunderson, Ramirez, Levine, & Beilock, 2012; Hall, Davis, Bolen, & Chia, 1999). Studies have found that parent's gender stereotype beliefs impact the way their own children view their mathematical ability. Tobias (1993) explained that parents of girls expected them to be nonmathematical. Jacobs (1991) found that among parents of 6th through 12th grade students, parents of girls hold stronger gender stereotypes favoring boys in math than parents of boys. In short, parents who believe in a gender stereotype tend to extend that belief on their own children. Gunderson et al. (2012) concluded that children's math attitudes form as a result of their home environment, especially interactions with parents.

Engelhard (1990) investigated the relationship of mathematics performance to math anxiety, mother's education, and gender. National samples were collected of 13-year old children in the United States and Thailand. The total sample consisted of 4,091 students from the United States and 3,613 students from Thailand. Math anxiety was measured using a 5-item scale. Results showed math anxiety had a significant effect on mathematics performance after controlling for the effects of previous achievement in mathematics, mother's education, and gender, $F(1, 4074) = 49.22$, $p < .01$. The Thai data suggested that the mathematics performance of girls may be more dependent on the level of the mother's education than the performance of boys, which does not appear to be the case in the American sample.

Further, Hall et al. (1999) examined gender and racial differences in mathematical performance among fifth and eighth grade students in the United States. Math performance was assessed by scores on the math-concepts and math-computation sections of the California Achievement Test given at the end of the previous year. A parent questionnaire reported the parents' education level in relation to the child's math performance, parents' self-reported math

anxiety, and parents' most advanced math course. Results showed negative correlations between all three math scores for the child and the parents' self-reported levels of anxiety about their own math skills. The less anxiety the parents reported about their math performance, the higher the child's score on the CAT math sections. Parental exposure to higher level math courses as well as parental education level was positively correlated with their child's math performance on the CAT.

Parental attitudes about liking mathematics when they were students and the importance of mathematics in society are extremely influential in their students' performance in math. Hall et al. (1999) explained that "parents appear to form their impressions of their child's interests and abilities in general on the basis of their own biases and to communicate their beliefs about math and its utility through their individual practices" (p. 681). If parents were poor at mathematics they had horrible mathematical experiences. If mathematics came easy to parents then they struggle to understand how it feels to be slow at mathematics (Tobias, 1993).

Parents can increase or decrease a child's excitement about math or their anxiety about math. Boaler (2008) stated famous mathematicians were inspired by problems and puzzles given to them by family members at home and not inspired by school teaching. If you give a child a set of pattern blocks, they will do all sorts of mathematical procedures. "One of the very best things that parents can do to develop their children's mathematical interest is to provide mathematical settings and to explore mathematical patterns and ideas with them" (p. 175). Parents are the ultimate starting block in a child's mathematical journey. The next step is to explore the teachers' role of influencing math anxiety.

Teacher Role

Teachers are important and influential members of our society. When an individual decides to become a teacher, they are choosing to make a difference in a young person's life. Whether it is teaching elementary school, middle school, high school, or post-secondary, being a teacher is a proud moment in an individual's life. There are reasons why a person teaches at an elementary school (kindergarten through fifth grade) or at the secondary level (sixth through twelfth). The typical elementary teacher is trained in all content areas while in pursuit of a teaching degree. The typical secondary teacher is trained in one subject (mathematics) while pursuing a college degree. Boaler (2008) found that several elementary teachers surveyed found math to be difficult as a student. Several elementary teachers felt comfortable teaching something other than mathematics. When it came to teaching mathematics, they felt discomfort and wanted to avoid the subject.

There are many challenges being an elementary teacher. When planning instructional lesson plans, elementary teachers have felt overextended while trying to prepare for so many different subject lessons. At times, planning mathematical lessons are just too demanding and complicated. Secondary teachers teaching mathematics typically specialize in the subject area and find it to be enjoyable. Middle school teachers in Colorado are highly qualified in the area they teach. To be highly qualified, teachers need to have 24 credit hours in the subject area they teach or pass the state test. Middle school teachers have a high level of comfort in the area they teach.

When it comes to helping a student in math, a teacher is the most influential factor. Teachers are impactful, teachers are role models, and teachers are passionate. Teachers strive to do the best they can to help a student succeed in math and in life. Boaler (2008) stated even if

teachers used outdated methods, they still have the best intentions to help a child succeed. "A major worry for teachers is likely to be how to keep pupils on-task" (Orton, 1994, p. 110). Teachers must monitor the type of discussions taking place in the classroom. There is an inordinate amount of structure that takes place to stimulate mathematical conversations and activities.

Demanet and Van Houtte (2012) stated that "teachers' attitudes can have a profound impact on students' education growth" (p. 860). Teachers who have low expectations for students tend to have disruptive behavior in the classroom. A teacher's attitude shapes the treatment of students. When a student perceives a teacher having low expectations for them, they show less academic progress and will tend to act out more in a negative way. The study was a multilevel analysis of discipline data from 11,844 students and 2104 teachers in 84 Flemish secondary schools. The study concluded that school-wide beliefs among teachers regarding students' teach-ability are associated with behavior problems. "Regardless of student's prior achievement, those attending schools where teachers consider students to be less teachable have a higher likelihood of being deviant" (p. 867).

Bekdemir (2010) examined pre-service teachers' math anxiety related to depth of negative experiences in mathematics classroom while they were students. The 167 participants were elementary pre-service teachers. The results showed many pre-service teachers had mathematics anxiety and had horrible experiences in math classrooms. This study found teachers high levels of math anxiety were caused by the instructors' hostile behavior, inadequacy of the instructors, and peer pressure. Other findings revealed significant differences in anxiety levels between those who reported the worst experience in mathematics classrooms and those without the worst experience (t=4.2, $p < .05$). The quantitative analysis showed that 9th through

11th grade students emerged with the first signs of math anxiety. This was caused by teachers' attitude and teaching approaches. Students expressed that they received no help or support from their teachers when they had difficulties or needed extra help. It was also pointed out that mathematical subtopics gradually become more abstract and more complex as the grade level increased.

When it comes to a teacher's role in elementary school, Belilock, Gunderson, Ramirez, and Levine (2010) showed when female elementary school teachers had high math anxiety their math anxiety carries negative consequences for the math achievement of their female students. First and second grade female teachers completed a math anxiety survey and the math achievement of their students' was assessed. There was no correlation between a teacher's math anxiety and of their students' math achievement at the beginning of the year. However, interesting results were discovered by the end of the school year. The higher a teacher's math anxiety the lower the girl's math achievement. Techer's math anxiety did not affect the boy's math achievement. Data analysis showed at the beginning of the school year for girls (r = -0.13 p = 0.31) and boys (r = 0.12 p = 0.40) and at the end year girls with (r = -0.28 p = 0.0221) and boys (r = -0.04 p = 0.81). The researchers speculated "that having a highly math-anxious female teacher pushes girls to confirm the stereotype that they are not as good as boys at math, which, in turn, affects girl's math achievement" (p.1861).

Scapello (2007) reported that teachers are a key element in reducing math anxiety and the key component for encouraging students to access higher level mathematics. "If we are to improve the educational opportunities of America's children, then we need to work with teachers, not against them" (Boaler, 2008, p.202).

Classroom Experience

In the 1980's students were failing mathematics in shockingly high numbers, and a range of reforms were introduced into schools. The National Council of Teachers of Mathematics (NCTM) issued a new set of curriculum standards in 1989 (Boaler, 2008; Tobias, 2007). Teachers started to teach mathematics using more groups and less lecturing and direct instruction. The problem was not about students solving problems but teachers were not trained in the new ways of teaching mathematics.

The classroom is ultimately the learning space where students are taught mathematics. The structure of a classroom and the instruction inside is most important. Picture a classroom in which children are highly engaged in solving math problems through debating their solutions (Alsup, 2005; Ashcraft and Kirk, 2001; Tobias, 2003). The whole class is engaged in discussions and using manipulatives to prove and justify their answers. Alsup (2005) explained that using a constructivist approach to instruction helped decrease the level of math anxiety and gains in students. After completing the Algebra I course using a constructivist approach, students became less anxious about math and were more empowered with regard to their own learning. The findings were reassuring knowing that a student's classroom experience may increase or decrease math anxiety.

Decreasing a student's math anxiety by focusing on the classroom experience is not the only important aspect for academic achievement. Another deciding factor is the way our brain de-constructs information and stores it. Through classroom experiences, students solve problems using their active working memory. Levine (2002) described active working memory serves as four specific tasks: a) provides mind space for developing ideas; b) is an apparatus for holding together the parts while solving a task; c) a meeting place for short-term and long-term memory;

and d) serves as a place to hold multiple plans. "Active working memory lets a child remember the stuff at the top of a page while reading the last few sentences of that page" (Levine, 2002, p. 100). To build success in mathematics, information must move from the active working memory to the short-term memory then become stored in the long-term memory. However, a student experiencing math anxiety struggles to move information from their working memory to short-term memory. A student's active working memory has an effect on math anxiety and ultimately determines a student's math performance. Ashcraft and Kirk (2001) found that individuals with higher levels of math anxiety showed significant lower working memory capacity scores than those of lower anxiety levels. This information forces educators to build structures during instruction to actively engage the memory of students.

Attitude on Performance

Previous negative mathematical experiences have detrimental effects on the attitude of students when it comes to math performance and achievement (Beilock, 2008; Boaler, 2001; Pajares & Miller, 1995). These negative mathematical experiences are determined by the individual student. A fear of looking stupid in front of the class can cause a negative experience. Being placed in the wrong math class can create a negative attitude especially if the class was above a student's competency level. Not coming to class prepared or ready to learn, adds to the list of how students develop poor attitudes towards mathematics. With this negativity, students enter the math classroom with hatred towards a subject that society has deemed important. A positive attitude and self-image essentially will help battle math anxiety in the classroom. This positive attitude continues to be significant for achieving success in mathematics and decreases math anxiety in students.

Boaler (2002) and Beilock (2008) suggested that another reason math anxiety exists was due to the method behind instruction and how students are tested. Traditional math classes focused on memorizing procedures and facts and provide little differentiation for individual needs. Mathematics was an organized body of knowledge, but the process of getting to knowledge was disorganized. During the process of knowledge, focusing on the students' metacognition will help change the instruction and help improve students' attitude about solving mathematical problems (Orton, 1994; Yeo, 2003). Yeo (2003) stated that math was difficult in many ways. Basic arithmetic skills are very multi-layered and must be taught in a sequential process. Children need to learn the basic foundation before trying to master skills and concepts. This will help students improve their attitude about performance in mathematics.

Instruments to Measure Math Anxiety

Different instruments have been used to measure math anxiety. The most commonly used math anxiety measurement tool was created by Richardson and Suinn in 1972. Wigfield and Meece created a shorter version of a math anxiety measurement tool called the Student Attitude Questionnaire (SAQ) for students in 6th through 12th grade in 1998.

Mathematical Anxiety Rating Scale (MARS)

The Mathematical Anxiety Rating Scale (MARS) was developed in 1972 by researchers Richard and Suinn. MARS is the leading instrument used when measuring math anxiety. MARS was a 98-item rating scale that used a 1 to 5 Likert-type scale measuring how anxious respondents feel in situations ranging from formal settings, informal settings and everyday situations. Most of the items on the MARS were "worded to describe practical situations that involve mathematics, *e.g.*, 'working on an income tax form,' 'checking over your monthly bank

account,' or 'figuring the sales tax. A few items depict academic test situations that concern mathematics and thus tap examination" (Suinn, et al., 1972, p. 373).

Ashcraft and Moore (2009) identified a number of problems with the MARS instrument: the length of time it took to administer, the wide range of scores from 98 to 490, and the availability of shorter instruments for researchers to use. Several adaptations were developed to replicate the style of questions used in the MARS, but researchers wanted to decrease the amount of time it took to complete the assessment; researchers also wanted to be able to administer the instrument to younger ages.

Ashcraft and Kirk (2001) used the short Math Anxiety Rating Scale (sMARS), which was a 25-item version of the MARS. The sMARS assessed an individual's level of apprehension and anxiety about math using the same 1-5 Likert scale. The sMARS was tested and yielded a very high correlation with participants overall MARS scores (r=.96) and acceptable test-retest reliability (r = .746). Throughout the years different variations of the MARS was designed to measure math anxiety for various audiences: MARS-A for adolescents, MARS-E for elementary aged students.

PHCC Test Anxiety Questionnaire

Nist and Diehl (2014) developed a short questionnaire for determining if a student experiences a mild or severe case of test anxiety in 1990. It consisted of ten items such as: "I have visible signs of nervousness such as sweaty palms, shaky hands, and so on right before a test" to "I have difficulty choosing answers". The questionnaire used a 5 point Likert scale using the following coding: Never (1) , Rarely (2), Sometimes(3) , Often(4), and Always (5). After adding up all scores, total scores can range from 10-50. A score range of 10 to 19 indicates low

student test anxiety. A score range of 20 to 35 indicates a medium student test anxiety. A score range of 36 to 50 indicates that you are experiencing a high level of test anxiety.

Fennema-Sherman Mathematics Attitudes Scale

Jari Metsämuuronen (2012), a behavioral science faculty member at Helsinki University in Finland, compared mental structures of eighth-graders in different countries based on the Fennema-Sherman Test. The Fennema-Sherman test was developed by Elizabeth Fennema and Julia Sherman in 1976 to assess the presence of math anxiety in high school students. It was intended to measure feelings of anxiety and nervousness associated with doing mathematics. It included nine domains: (a) attitude toward success in mathematics scale, (b) mathematics as a male domain scale, (c) mother scale, (d) father scale, (e) teacher scale, (f) confidence in learning mathematics scale, (g) mathematics anxiety scale, (h) reflectance motivation scale in mathematics, and (i) mathematics usefulness scale. The test used Likert scales to measure attitudes towards learning mathematics. Metsämuuronen's study used a shorten version of the Fennema-Sherman Test only including two questions. The overarching question was "How much do you agree with these statements about learning mathematics?" Question 8 and 9 are as follows:

Question 8:

a. I usually do well in mathematics,

b. I would like to take more mathematics in school,

c. Mathematics is more difficult for me than for many of my classmates,

d. I enjoy learning mathematics,

e. Mathematics is not one of my strengths,

f. I learn things quickly in mathematics,

g. Mathematics is boring,

h. I hate mathematics.

Question 9:

a. I think learning mathematics will help me in my daily life,

b. I need mathematics to learn other school subjects,

c. I need to do well in mathematics to get into the University of my Choice,

d. I need to do well in mathematics to get the job I want.

Defining High/Low Math Achievement

Defining high math achievement and low math achievement in the educational setting was difficult. If grades were used as criteria to define math achievement, then the traditional A and B letter grade would define high math achievement, C letter grade would define average, and D and F letter grade would define low math achievement. Bluntly stated, the American grading system is broken and should not be used to define math achievement. Many grades in a teacher's grade book measure effort and not ability based on state standards. Getting a parent signature on a syllabus does not show a student's academic ability but rather their effort of taking the syllabus home for a parent to sign. O'Connor (2007) pointed out that grades need to be consistent, accurate, meaningful, and support learning. Students should earn the same grade no matter what teacher they have. Grades need to express information useful to all stakeholders and show evidence of achievement.

For the purpose of this study, high and low math achievement was defined by student performance on TCAP. According to the Colorado Department of Education (2012), the Performance Level Scale Score Range for CSAP Assessments was used to score the Transitional Colorado Assessment Program. The researcher defined high math achievement as scores in the

proficient and advanced range. Low math achievement was defined as scores in the partially proficient and unsatisfactory range. Table 1 presents the performance level scale score range for TCAP assessments score in each category.

Table 1. *Performance Level Scale Score Range for TCAP Assessments*

Content Area	Grade	Unsatisfactory	Partially Proficient	Proficient	Advanced
Mathematics	6th	240-453	454-519	520-588	589-830
Mathematics	7th	280-486	487-558	559-613	614-860
Mathematics	8th	310-520	521-576	577-627	628-890

Mathematical Assessments

There are different ways to assess a student's mathematical understanding. Classroom teachers use formative assessments and summative assessments to gauge the depth of knowledge in students. Schoenfeld (2007) explained the idea of assessment in a very plain and simple way. If you want to know what a student knows, write some questions down about the content you want examined and see if the answers are right or wrong. Then add up the total score to see if they know the content or not. Math assessments should reflect the mathematical content, processes, and understand mathematical thinking behind solving problems.

During 2012, Transitional Colorado Assessment Program (TCAP) was the standardized test used to assess student achievement. Colorado students take TCAP in March, even though, students start school late August. Essentially, students take the state test during their seventh month of school with two months left. The American public school is typically nine months long ending in late May. Students at the researcher's middle school attend school 173 days. This traditional calendar continues to be of grave concern to educators and schools boards across the United States.

In the researcher's school district, middle school students take the Acuity Mathematics Assessment created by McGraw Hill twice a year. Acuity was an instrument used by math teachers to benchmark students' level of competency as they enter the classroom. Acuity's number one goal was to help teachers predict, diagnose, report, and change instruction to meet the learning needs of students. It was administrated during a single class period for 65 minutes. Acuity measured performance and helped focus instructional time in mathematics. It informed instruction by outlining exactly where to concentrate teaching efforts, and provided teaching tools to help improve performance. Acuity enables educators to predict students' mathematical performance on the Transitional Colorado Assessment Program (TCAP). The results helped teachers assess their own instruction and student results.

Transitional Colorado Assessment Program (TCAP)

According to the Colorado Department of Education's (2012) the Transitional Colorado Assessment Program was a standards-based assessment designed to provide a picture of student performance. TCAP was given to every Colorado 3rd through 10th grader during a four week window beginning in March. Sixth, 7th, and 8th graders were given six 55-minute assessments in reading and writing and three 65-minute assessments in math. Eighth graders were the only middle school grade level to take a science assessment. The purpose of TCAP was to determine a student's level of meeting the Colorado Content Standards.

The individual student data helped teachers inform instruction and evaluate each student according to state standards. The assessment was formerly known as the Colorado Student Assessment Program (CSAP) but changed to reflect the new Colorado Assessment Standards. CSAP has been in existence for the past 17 years.

Student performing at grade level and showing academic growth from year to year was the expectation. According to Colorado Department of Education's (CDE) website, as of December 2010, Colorado Department of Education introduced the new Common Core Standards, which decreased the Model Content Standard from six to only four standards. The Colorado Academic Standards in mathematics are the topical organization of the concepts and skills every Colorado student should know and be able to do throughout their preschool through 12th grade experience.

1. Number Sense, Properties, and Operations

Number sense provides students with a firm foundation in mathematics. Students build a deep understanding of quantity, ways of representing numbers, relationships among numbers, and number systems. Students learn that numbers are governed by properties and understanding these properties leads to fluency with operations.

2. Patterns, Functions, and Algebraic Structures

Pattern sense gives students a lens with which to understand trends and commonalities. Students recognize and represent mathematical relationships and analyze change. Students learn that the structures of algebra allow complex ideas to be expressed succinctly.

3. Data Analysis, Statistics, and Probability

Data and probability sense provides students with tools to understand information and uncertainty. Students ask questions and gather and use data to answer them. Students use a variety of data analysis and statistics strategies to analyze, develop and evaluate inferences based on data. Probability provides the foundation for collecting, describing, and interpreting data.

4. Shape, Dimension, and Geometric Relationships

Geometric sense allows students to comprehend space and shape. Students analyze the characteristics and relationships of shapes and structures; engage in logical reasoning, and use tools and techniques to determine measurement. Students learn that geometry and measurement are useful in representing and solving problems in the real world as well as in mathematics.

The Common Core State Standards (CCSS) establish grade-level expectations in mathematics and English language arts for K-12 students. According to the Center for Public Education (2013) these Common Core State Standards describes the knowledge and skills students are expected to develop as they progress through public education. The CCSS are internationally benchmarked and are aligned with college and work expectations. These basic building blocks guide our decisions as educators on what we teach in the classroom and the different programs we have available to our middle school students. A student's proficiency level determines if they are at grade level or below grade level. Student achievement is determined by a scale score on the previous year's Transitional Colorado Assessment Program (TCAP) test.

National Assessment of Educational Progress (NAEP)

Mathematics achievement in the United Stated was measured by the National Assessment of Educational Progress (NAEP) also known as the nation's report card. This national assessment measured what American students knew and were able to do. According to the Colorado Department of Education (2014) www.cde.state.co.us/assessment/conaep, the major goal of NAEP testing is to measure student achievement and change in growth. Nationwide 170,100 eighth-grade students in 6,520 schools participated with Colorado having 2,700 eighth-grade students in 111 schools participated. Both the NAEP 4th grade and 8th grade mathematics

scales range from 0 to 500. Table 2 shows the achievement levels for eighth grade students on the National Assessment of Educational Progress (NAEP).

Table 2. *National Assessment of Educational Progress (NAEP) math achievement levels*

Achievement Levels	Scale
Below Basic	261 or lower
Basic	262-298
Proficient	299-332
Advanced	333 and above

Results from NAEP testing in 2013, Colorado's average scale score for students in grade 8 math was 290. This was significantly higher than the score across the nation of 284. Colorado's average scale score of 290 is not significantly different than the 2011 score of 292 and has remained flat since the 2007 test of which 286 was the average scale score. The score of 290 is rated as basic.

Achievement Differences

Research differed in studies measuring math anxiety between girls and boys. Boaler (2008) pointed out that new research found that women and men use different areas of their brain to solve problems. Women and men have the same intelligence which means they both have the same number of brain cells. Tobias (1993) stated most boys attribute their success in math to ability while girls attribute their math success to consistent effort. This attitude in some girls will lower their expectations in future mathematical successes. Geist (2010) explained that math classes use a very traditional skill based model of teaching. This skill-based model is about memorization or repetition instead of active learning. Math is often taught as if all students are the same, meaning girls and boys learn in the same manner and by using the same procedures.

Wigfield and Meece (1998) assessed math anxiety in 564 6th through 12th grade students as a comprehensive longitudinal investigation of beliefs, attitudes, and values concerning mathematics. It was determined that girls reported stronger negative emotional reactions to math than did the boys. The worry component in the study consisted of the self-thoughts on one's performance in mathematics. Ninth-grade students reported experiencing the most worry about math, while sixth graders had the least amount of worry. Individuals with high math anxiety performed at a lower level on standardized math tests. The study concluded that the gender differences for the boys' and girls' responses to the math anxiety questionnaire had no difference. Meaning the boys and girls answered the items on the questionnaire in similar ways. Also, boys and girls did not differ in their reports of math worry indicating that they were equally concerned about doing well in mathematics.

That boys are better in math than girls was the stereotype most commonly expressed. Begley (2012) explained that in the U.S., the ratio of boys to girls scoring above 700 on the math SAT fell from 13:1 in the 1970's to 3:1 in the 1990's. Boaler (2008) stated that at age 16 all students take the General Certificate of Secondary Education (GCSE) in England. Girls passed the exam at a higher rate than boys. Boaler (2008) explained girls were outperforming boys in the subjects of mathematics and physics. Interesting, women made up 47% of mathematics majors while only 27% of mathematics PhDs went to woman. In 2003, woman made up only 8% of the mathematic faculty in America.

The "girl" problem has been a problem between girls and mathematics (Secade, 1995). The phrase implies that the problems were caused by girls, as if they are doing something wrong or lacking skills in mathematics. Traditionally girls have shown less interest in mathematics than boys maybe due to the treatment girls and boys receive in school. Elias and Bruene Butler

(2005) stated that social pressures during the middle school years damage girl's self-esteem. This damage creates a loss of interest and confidence in math and science related careers. Tobias (1993) pointed out that some teachers believe boys naturally do better in math than girls do. When a boy fails a math quiz, their excuse is they did not work hard enough. But when a girl fails the same math quiz, their excuse is that they simply cannot do math.

Cheema and Galluzzo (2013) used a multiple regression framework to predict math achievement from different variables. Variables included gender, math anxiety and math self-efficacy. The Program for International Student Assessment (PISA) 2003 student questionnaire of 4,733 observations was used. The target population for this survey was 15-year old high school students in the U.S. Of the 4,733 students (boys, n= 2,345; girls, n = 2,388). The math anxiety scales used was based on five items that assessed student feelings of helplessness and emotional stress when confronted with mathematical tasks. The math self-efficacy scale was formed from eight items that measured student confidence in tackling simple math problems. A simple one-way analysis of variance (ANOVA) was fitted to determine whether mean math achievement differed across categories of these variables. The ANOVA of math achievement on gender was significant, $F(1, 4732) = 7.49$, $p = .006$, suggesting that there was a significant difference between boys and girls in terms of average math achievement, with mean achievement of boys (M =.06, SD 1.06) exceeding that of girls (M = -0.03, SD = .97) This translated into the boys having approximately eight average points higher than girls. Once math anxiety was added to the list of predictors of math achievement amongst the gender, the standard deviation was -0.20 meaning a genders math anxiety or self-efficacy does not contribute to their math achievement. According to this study, when math-specific student characteristics, such as math

self-efficacy and math anxiety, are properly controlled, students tend to perform equally well on math despite their gender.

Student Attitudes towards Mathematics

Beilock (2008) stated that calculating a problem in one's head involves several steps. In some students, these steps create a stressful situation. These situations often cause individuals to perform poorly. According to Beilock,

> "The expression 'chocking under pressure' is used to describe what happens when people perform more poorly than expected given their skill level precisely because there are large incentives for optimal performance and highly negative consequences for poor performance." (p.339)

Heibert (1986) stated it is obvious when a mistake is made. Some mistakes are the result of inattention or sloppiness and do not reveal a lack of understanding of the process. Unlike literacy classes or questions around author's purpose, mathematics is more focused on a single solution. The problem 2+2 has only one answer and is not abstract or complex. A mathematics student must know how to solve a problem and understand the concept it applies to.

Heibert (1986) continued to state that when a student does not value math or understand how it applies to everyday life, this attitude decreases their motivation to do well. When a student has low motivation for a subject, they become less likely to try hard in that class. In math class, that attitude has devastating outcomes. Concepts are spiraled throughout a set curriculum, and sometimes mastery is needed before moving forward to another concept. A student cannot become successful with multiplication if understanding the process of addition is not mastered.

Achievement Goal Theory

Achievement theory in the sports arena was similar to the academic achievement in the classroom arena. Hanchon (2011) concluded that American society has become fixated on

performance outcomes and declaring who is the best. Wanting to always win at all costs or getting perfect grades is becoming an epidemic across America. Parents expect the best out of their children and penalizing them for when those expectations are not achieved.

The days are long gone when you played a sport because it was fun and interesting or take a class because you are curious about a certain topic. Families spend thousands and thousands of dollars for their child to participate in club sports with the hope of one day their child will earn an athletic scholarship. Rarely do parents spend money on mathematics tutors to help improve competency or help overcome mathematics anxiety.

In this day and age, parents are more excited to tell friends and family about how amazing their child is at a certain sport instead of talking about their child's mathematics competency level. Parents love bragging about their kids. This type of parent behavior has psychologically impacted student athletes across the country. It is a devastating conundrum for student athletes who are praised for winning or criticized for losing. Hanchon (2011) explained that winning was often viewed as an all or nothing virtue. Greatness is only reserved for those whose names appear at the top of the list or on the trophy for first place. The message is clear. Only one's final results matter, regardless of his/her effort. Parents would rather spend money on a hitting coach than on a math tutor.

Hanchon (2011) defined success in terms of competitive results or peer-referenced standards. This model seems especially applicable within our education system. When report cards go home, parents look for the non-A's to criticize. The expectation of receiving all A's to improve a student's grade point average (GPA) is our current societal norm. Receiving A's on a report card is similar to winning the game of school. Earning straight A's is believed to be how you "win" in the academic arena. To most parents, academic achievement is seen as earning the

top grade in elementary and middle school or having the highest grade point average in high school. Enormous pressure is put on students to do their best and nothing less than an A is acceptable.

Mathematical Self-efficacy

Self-efficacy is the degree in which a student believes that he or she is capable of performing specific tasks (Ashcraft, 2002; Geist, 2010; Hembree, 1990). There has been an increasing emphasis on the importance of math-related fields to the US economy. Too many students are avoiding fields involving mathematics. In the current high-stakes testing environment, there is a need to identify an attribute that can positively influence achievement (Falco, Summers, & Bauman, 2010; Fast et al., 2010). Self-efficacy was an attribute that could change how students perform in the classroom and how they view themselves as capable learners of mathematics.

Fast et al. (2010) pointed out that whether students perceive their classroom as a caring environment has a powerful influence on self-efficacy. Caring attitudes by teachers and other students is a part of creating self-efficacy in a student's view of mathematics. More importantly,

> "teachers of middle school mathematics should have a deep conceptual understanding of the elementary mathematics taught in middle school, should possess the mathematics knowledge for teaching that is required to effectively teach mathematics in middle school and should have the ability to effectively teach mathematics to, and enhance the math's self-efficacy of, a culturally and socially diverse middle school student population." (Stevens, Harris, Aguirre, & Cobbs, 2009, p. 903)

Teachers have a direct impact on students' knowledge of mathematics and how this knowledge relates to a student's mathematical self-efficacy.

Luo et al. (2009) analyzed 311 valid questionnaires from middle school students in west China. A class was selected at random from 7th through 12th grade. All subjects were the only child from middle-income families. There was a significant negative correlation of -0.576

between self-efficiency and mathematics anxiety. The result indicates that the more confidence students have, the less mathematics anxiety they may have.

Table 3. *Literature Review Matrix*

Reference	Purpose	Research Question	Sample	Findings
Ashcraft, M. H., & Kirk, E. P. (2001). The Relationships Among Working Memory, Math Anxiety, and Performance. *Journal Of Experimental Psychology. General*, *130*(2), 224.	Research the possible cognitive consequences and correlates of math anxiety. Math anxiety has negative effects on math performance and achievement.	Examine the influence that math anxiety exerts on mathematical cognition and to identify the processing components that are so influence.	66 participants from a lower level undergraduate psychology classes. 10 item sheet asking demographic and math background questions.	Individuals with high math anxiety take fewer math courses, earn lower grades in the classes, and demonstrate lower math achievement and aptitude
Reference	**Purpose**	**Research Question**	**Sample**	**Findings**
Ashcraft, M. H. (2002). Math Anxiety: Personal, Educational, and Cognitive Consequences. *Current Directions In Psychological Science (Wiley-Blackwell)*, *11*(5), 181-185	Highly math-anxious individuals are characterized by a strong tendency to avoid math, which ultimately undercuts their math competence and forecloses important career paths.	Discussion of what has been learned about math anxiety across the past 30 years or so and suggest some pressing issues to be pursued in this area.	Review of material over years.	Highly math anxious individuals avoid math. They take fewer elective math courses, both in high school and in college, than people with low math anxiety.
Reference	**Purpose**	**Research Question**	**Sample**	**Findings**
Beilock, S. L. (2008). Math Performance in Stressful Situations. *Current Directions In Psychological Science (Wiley-Blackwell)*, *17*(5), 339-343.	Reviewed work suggests that a high-stress situation creates worries about the situation and its consequences that compete for the working memory normally available for performance.	Why does failure in math occur? Who is most likely to fail under pressure in math?	Researchers created a high stakes testing environment in a laboratory. Individuals were simply told to try their best.	Whether individuals are made aware of negative stereotypes, stress-laden environments can negatively affect math performance. Those who in the absence of

				pressure, have the greatest capacity for success.
Reference	**Purpose**	**Research Question**	**Sample**	**Findings**
Geist, E. (2010). The Anti-Anxiety Curriculum: Combating Math Anxiety in the Classroom. *Journal Of Instructional Psychology*, *37*(1), 24-31.	Negative attitudes toward math and what has come to be known as "math anxiety" are serious obstacles for children in all levels of schooling today. Literature is reviewed to the roots of math anxiety.	What are the roots of math anxiety? Does the effects of teachers and parents assumptions address to anxiety?	Review of literature; teacher influence, gender effects on negative attitudes, and poverty and family effects on negative attitudes	Many teachers who have math anxiety themselves inadvertently pass it on to their students. Math anxiety does not come from the mathematics itself but rather from the way math is presented in school and may have been presented to teachers as a child.
Reference	**Purpose**	**Research Question**	**Sample**	**Findings**
Haiyan, B., LihShing, W., Wei, P., & Frey, M. (2009). Measuring Mathematics Anxiety: Psychometric Analysis of a Bidimensional Affective Scale. *Journal Of Instructional Psychology*, *36*(3), 185-193.	To develop a theoretically sound bi-dimensional affective scale measuring math anxiety.	Can an instrument be created to measure math anxiety?	Sample of 78 undergrad students from different disciplines, enrolled in a math course from a Midwest community college. 36 males and 42 females between the ages of 18 and 24.	Math anxiety suggests that this instrument can serve as a research tool for investigating framework of the construct.
Reference	**Purpose**	**Research Question**	**Sample**	**Findings**
Newstead, K. (1998). Apsects of children's mathematics anxiety.	To find out if a different teaching approach creates less math anxiety.	Math anxiety questionnaire scores will be multidimension al.	246, 5 and 6 year old pupils in 5 mixed-sex primary schools in a rural U.K. environment.	One of the most significant findings was that children

Educational Studies In Mathematics, 36(1), 53.	Pupils who have been exposed to an alternative teaching approach will have lower average math anxiety total scores than pupils who have been exposed to a more traditional teaching approach.	MAQ was given	between the ages of nine and eleven reported a significant amount of anxiety of doing math in the presence of their teachers and peers in the classroom. Students exposed to communicating about math and working with others had less math anxiety.

Summary and Conclusion

In Chapter 2, emphasis was placed on math anxiety, math achievement, gender and math anxiety, and possible reasons for math anxiety. Math anxiety was found to exist in students of all ages. Sherman and Wither (2003) conducted a longitudinal study over five years on the relationship between mathematics anxiety and mathematics achievement. Three schools in Adelaide, South Australia, were measured twice a year over a period of five years starting in 6th grade to 10th grade. The study showed that there is a relationship between mathematics anxiety and mathematics achievement at a significant level.

Although math anxiety has been explored for decades by various researchers, there needs to be more research at the middle school level as demonstrated by Wigfield and Meece (1988).

Research is needed in earlier grades to understand when math anxiety occurs and the proper interventions to help alleviate the problem.

CHAPTER THREE: METHODOLOGY

Research Rationale

This chapter will describe the methodology for the study. The primary purpose of this study was to better understand the relationship between math anxiety and math achievement in sixth, seventh and eighth grade students attending a middle school in a small northern Colorado city. The second purpose was to determine if there was a statistically significant difference on math achievement between middle school students with low math anxiety and high math anxiety.

Research Design

The purpose of this quantitative study was to learn whether math anxiety was a factor of predicting student mathematical achievement. The study looked for differences in measures of math anxiety and math achievement by middle school grade level. A comparative research approach was used to gather data because "comparative designs usually have a few categories of the independent variable and make comparisons between groups" (Gliner, Morgan, & Leech, 2009, p.50).

The quantitative research approach was an ex-post-facto study and the type of design was between groups and grade levels. The statistical package IBM SPSS version 22 was used to analyze the results from the study. The researcher was interested in understanding the problem of math anxiety affecting student achievement scores at the middle school level. To begin, educators must have a way to identify the level of math anxiety of a student before differentiating instruction or implementing individual interventions. The math curriculum taught at the middle school for this study was College Preparatory Mathematics (CPM), which focused on common core standards.

By using the math questionnaire (MQ), the researcher was able to run data tables to see if math anxiety had an effect on student achievement at the middle school. Grades 6, 7, and 8, are the grades at the middle school. Student achievement was determined by the scale score on the previous year's TCAP score. "The Transitional Colorado Assessment Program (TCAP) is Colorado's standards-based assessment designed to provide a picture of student performance to schools, districts, educators, parents and the community" (Colorado Department of Education, 2015). Each student was scored in four categories: Advanced, Proficient, Partially Proficient, and Unsatisfactory. A student with high achievement will have scored an advanced or proficient score. A student with low achievement will have scored a partially proficient or unsatisfactory score on the TCAP test. Table 4 shows the math classes students are enrolled in at the researcher's Colorado middle school.

Table 4. *Middle School Math Classes by Grade Level and Class Level*

Grade Level	Class Level
6th grade	Math 1 or Math 1.5 focus class
7th grade	Math 2 or Math 2.5 focus class
8th grade	Math 3 or Math 4 focus geometry class

Math 1, 2, and 3 class was the regular mathematics class students take. The math focus classes will accelerate students in math by one year. When students complete the program, 9th graders will register for Algebra 2 as a freshman instead of registering for Algebra 1. The advantage for students is the opportunity to take higher level mathematical classes before they graduate from high school.

Each class period length was different for 6th, 7th, and 8th graders. Sixth grade students had math for 87 minutes a day except on early release Wednesdays. On early release Wednesday, students had math for 73 minutes. Seventh grade students had math for 50 minutes a day except early release Wednesdays, which was 42 minutes. Eighth grade students have math for 64 minutes a day except on early release Wednesdays, which was 53 minutes.

Sixth graders only have three core classes a day. Core classes consist of math year long, literacy year long, and science and social studies are a semester each. Seventh and eighth graders have four separate core classes. Those core classes are math, literacy, science, and social studies year long. Each grade level takes two different elective classes a semester with the rest of the periods being core classes. PE, Health, Computer Literacy, Art, Band, and Choir are considered elective classes at the middle school. Each class is a semester compared to a year-long core class.

A middle school student attends school 173 days in the researcher's school district. Students start school in August and end in May. With the exception of early release Wednesdays, each school day consists of 442 minutes. An early release Wednesday is only 342 minutes. All students have an advisory class for 40 minutes at the end of the school day starting at 2:07 p.m. and ending at 2:47 p.m. Advisory classes are designed by each team and assigned by the academic need of each student. Students are in intervention rotations for about three weeks. Most students were enrolled in a math, reading, and writing intervention. Those students who need fewer interventions have the opportunity to be enrolled in a team building or enrichment rotation.

School Demographics

The demographic of the school in this study was 21% free and reduced lunch, 88% Caucasian, 11% Hispanic, and 1% Asian and African American. The total enrollment was 460 students. For the 2013-2014 school year, there were 34 teachers of whom 8 are males and 26 females. The school was funded on a 21.5 student to teacher ratio. The researching principal was at the Northern Colorado middle school for nine years; seven as the principal and two as the assistant principal. The assistant principal of the middle school was in her first year as an administrator. Student's attendance was extremely high with a 94.6% attendance rate. The community strongly supports the school and their children's education. The community fund raised over a half of a million dollars in the past four years through silent auctions and business donations. The money helped support the two elementary schools, one middle school and one high school with technology and other needed resources.

Participants and Site

Thompson School District is located in Northern Colorado. Covering 362 square miles, Thompson School District is the 16th largest school district in Colorado. The district serves the cities of Loveland, Berthoud, and portions of Fort Collins and Johnstown. The district is a pre-K through 12th grade district with 20 elementary schools, five middle school, and five high schools. The district had over 16,000 students. The middle school used in this study was the smallest middle school of the five. The school has the highest academic achievement and consistently outperforms the other middle schools. The population for this study consisted of 464 participants. The sample was comprised of 137 sixth graders, 137 seventh graders, and 190 eighth graders.

Those students who returned the consent form to participate in the study within the one-week deadline were given the questionnaire during their mathematics class. Several make-up days were scheduled for students not present during the initial distribution of the questionnaire. The majority of the students participating in the study lived in the community; 8% percent lived outside of the community. All students enrolled in grade level math classes during the 2013 – 2014 school year were used in the study. Students who did not take the previous year's TCAP assessment did not participate in the study

Original Instrument's Validity and Reliability

The Math Anxiety Questionnaire used in the study by Wigfield and Meece (1988) defined six dimensions of anxiety or negative reactions to mathematics: dislike, lack of confidence, discomfort worry, fear and dread, and confusion/frustration. The MAQ completed by students in the Meece et al. (1990) study contained items having adequate variability and used the above factors. A principal-components factor analysis was done on the 11 item MAQ and was deemed valid and reliable. Both Kaiser's criterion and Cattell's scree test were used to select the number of factors. Using the Meece MAQ has been shown to have two advantages in research. Firstly, proctoring a 98-question math anxiety rating scale (MARS) with sixth, seventh, and eighth grade students is time consuming. The Meece MAQ was 11 questions long, but still reliable and valid. Secondly, the Meece questionnaire removed aspects of negative affect that are not directly related to anxiety. The Math Anxiety Questionnaire was actually given to high school students. The Math Questionnaire used in the pilot study at the researcher's middle school had 12 questions and used terminology understandable by middle school students. The 12 questions used appropriate language to make students better understand the math anxiety constructs being used.

Instrumentation and Development

The instrument used in this study was adapted from Meece's Math Anxiety Questionnaire (see Appendix A). As the researcher began thinking about this project, he wondered what middle school students would say about math. So, to test his assumptions that there might be anxiety around math, during the 2011 – 2012 school year, the researcher surveyed two eighth grade classrooms about their feelings toward mathematics. One of those classes was a grade level math class and the other one was intervention class for students who scored below grade level in mathematics on TCAP. Each student received a 3x5 index card and had five minutes to write down their feeling about mathematics. Table 5 shows how eighth grade students felt about mathematics. Note the similarity in responses between high achieving and low achieving students. These responses gave the researcher impetus to pursue the study.

Table 5. *Eighth Graders' Feelings about Mathematics*

Classroom Description	Words Used
8th Grade High Level Math Class	Stress, horror, difficult, book work, hard, stressful, never ends, terrible, exciting, easy, numbers, so-so, difficult, a lot of work, lots of thinking, confusion, boring, scared, waste of time, fine, annoying, tired, fun, boredom, sick, anxiety, hopelessness, calm, smart, frustration, happy, love, and hyper.
8th Grade Intervention Math Class	Stress, frightful, happiness, easy, hard, boring, struggling, grrrr, nooooo, not fun, seems pointless, boredom, tedious, nonessential, confusing, hard, useless, misunderstanding, nervous, sad, and frustrating.

Using Meece's Math Anxiety Questionnaire as a guide and terminology provided by eighth grade students, Table 5 refers to the questionnaire that was developed by the researcher to ensure that middle school students could understand the language. A Likert scale was added to

the new instrument to create a better understanding of where students were with their anxiety around math. The new instrument piloted in a single classroom during its development in order to check for reliability and validity on the construct of mathematics anxiety, as well as to get feedback from students about the language and their understanding of the questions.

The Revised Math Anxiety Questionnaire (see Appendix B) contained 12 questions on a 5-point Likert-type scale. A Cronbach's alpha was used to measure the internal consistency reliability of the instrument in the pilot study. "Alpha is based on a correlation matrix and is interpreted similarly to other measures of reliability" (Morgan, Leech, Gloeckner, &Barrett, 2011, p. 135). The Chronbach's Alpha of .888 is highly reliable showing that the items being measured are using the same construct (math anxiety).

After creating the questionnaire, the researcher visited an eighth grade literacy classroom during the 2011 – 2012 school year to ask students if they understood the wording in each statement. The researcher read each statement to the students and students put a thumbs-up if they understood it or a thumbs-down if they did not understand the statement. There were no students who put a thumbs-down to any of the statements. Several questions were asked by the researcher to make sure students were not just putting their thumb up because that was what the rest of the class was doing.

The new instrument was titled Math Questionnaire (MQ) instead of the more negative Math Anxiety Questionnaire. Including the work anxiety in the title might have suggested a negative impression about math to the students. Instead, the script used during the distribution of the MQ stated students would rate their feeling about math not about their anxiety towards math (see Appendix C).

Three of the questions, questions #5, #8, and #12, from this iteration were not included in the final instrument because of negative wording and redundancy. This left nine questions related to the construct of math anxiety from the original instrument. They were added purely as a curiosity on how students view their resources (parents and teachers), and comparing their feeling of literacy to math.

Validity and Reliability of the Math Questionnaire (MQ)

To measure the appropriateness of the Math Questionnaire (MQ), an exploratory factor analysis was run, yielding the following results in Table 6. KMO equals .897 (factor analysis should yield distinct and reliable factors). The researcher was confident that the factor analysis was appropriate for the data; Bartlett's test of Sphericity yields a significant value $p<.001$, therefore, factor analysis was appropriate.

Table 6. *KMO and Bartlett's Test*

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Bartlett's Test of Sphericity Approx. Chi-Square	*df*	*Sig*
.897	1156.371	36	.000

Table 7 shows the exploratory factor analysis correlation matrix with significance on all comparisons, $p<.001$. Upon first look, all questions in the MQ correlate well and none of the correlation coefficients are large, therefore, there was no need to consider eliminating any questions at this stage.

Table 7. *Correlation Matrix*

	Nervous	Worry	Stressed	Frustrated	Sleepy	Extra Help	Won't Ask	Test back	Butterflies
Correlation									
Nervous	1.00	.487	.530	.438	.404	.433	.309	.367	.538
Worry	.487	1.00	.506	.492	.269	.476	.275	.469	.401
Stressed	.530	.506	1.00	.486	.365	.484	.290	.471	.493

Frustrated	.438	.492	.486	1.00	.195	.558	.316	.368	.377
Sleeping	.404	.269	.365	.195	1.00	.349	.242	.354	.417
Extra Help	.433	.476	.484	.558	.349	1.00	.350	.450	.384
Won't Ask	.309	.275	.290	.316	.242	.350	1.00	.383	.303
Test Back	.367	.469	.471	.368	.354	.450	.383	1.00	.408
Butterflies	.538	.401	.493	.377	.417	.384	.303	.408	1.00
Sig. (1-tailed)									
Nervous		.000	.000	.000	.000	.000	.000	.000	.000
Worry			.000	.000	.000	.000	.000	.000	.000
Stressed	.000	.000		.000	.000	.000	.000	.000	.000
Frustrated	.000	.000	.000		.000	.000	.000	.000	.000
Sleeping	.000	.000	.000	.000		.000	.000	.000	.000
Extra Help	.000	.000	.000	.000	.000		.000	.000	.000
Wont Ask	.000	.000	.000	.000	.000	.000		.000	.000
Test Back	.000	.000	.000	.000	.000	.000	.000		.000
Butterflies	.000	.000	.000	.000	.000	.000	.000	.000	

Determinant = .046

Table 8 showed the factor loading for each variable (two were requested) in the Rotated Component Matrix. With the exception of the "sleeping" question, each variable loaded most strongly on Factor 1: Mathematics Anxiety. Though the "sleeping" question loaded most strongly on Factor 2, it loaded as strong on other questions, so was not considered for elimination.

Table 8. *Component Matrix*[a]

	Component	
Factor	1	2
Nervous	.740	.169
Worry	.721	-.251
Stressed	.764	-.011
Frustrated	.695	-.466
Sleeping	.563	.658
ExtraHelp	.734	-.244
Won't Ask	.535	-.063
Test back	.691	.001
Butterflies	.704	.325

Extraction Method:

Principal Component
Analysis
2 components extracted

Consent to Participate

Because middle school students are considered minors, parental permission was required for all participants in the study. On February 20, 2014, the researcher went into each sixth, seventh, and eighth grade math classroom to discuss the purpose of the study and distribute consent forms (See Appendix D) to students. The consent form was explained to each student and the researcher explained the option to participate or not to participate. Since middle school students have a habit of forgetting and losing material, the consent form was emailed to every middle school parent explaining the rationale for the study. Each student who planned to participate signed their name on the consent form indicating they received the three-page document. Each day thereafter for one week, the researcher went back into math classrooms to collect signed consent form. The signed consent forms were filed by teacher in two three inch binders labeled CSU research project. Once the researcher had more than 80% of the school's consent forms returned, a distribution date for the Math Questionnaire was scheduled. All information collected in this study was maintained with the highest level of confidentiality.

Instrument Distribution

Once the researcher had more than 80% of the school's consent forms returned, he set a distribution date. The researcher went into each sixth grade math classroom on February 27, 2014 and seventh and eighth grade math classrooms on February 28, 2014 to give out the math questionnaire. The researcher passed out and explained the assent form (Appendix E). After reading the assent form, students wrote their name, grade level, and elementary school they attended in fifth grade at the top of the Math Questionnaire. A script was used to standardize the

directions and proctoring of the Math Questionnaire (Appendix F). Once the students were given permission to begin they finished in less than 10 minutes. The finished MQ was collected and stored in safe and secure area.

Data Collection Procedures

The IRB protocol ID 13-4612H was obtained and approved on February 12, 2014. Approved student participants were given 12 statements related to their feeling about mathematics on February 27, 2014 and February 28, 2014. The participants had to rate themselves on a 5-point Likert-type scale of their feeling toward mathematics. The 12 statements were designed for a quantitative analysis (Appendix A). After students completed the survey, the researcher collected the questionnaire and totaled the points on each sheet. The Math Anxiety Likert Scale and point value are listed in Table 9.

Table 9. *Math Anxiety Likert-Scale Response Choices*

Response Choice	Point Value
Never	1
Rarely	2
Sometimes	3
Often	4
Always	5

The total possible point value for each statement was five and the minimum was one. The highest possible points for the questionnaire were 45 and the minimum were nine. Three statements (Statement 5, 8, and 12) were excluded from total score because they were informational or descriptive questions only, not part of the math anxiety factor. The higher the score, the more anxious a student feels about mathematics. An Excel document was creating

recording a student's name, grade level, elementary school, TCAP scale score, proficiency level, and answers to each math questionnaire statement.

Research Questions and Data Analysis

The purpose of this study was to investigate the influence math anxiety has on student achievement. Following are the research questions:

1. What is the association between math anxiety and achievement on TCAP in mathematics?

   The purpose of this question was to compare the association between math anxiety score of sixth, seventh, and eighth grade students on the TCAP assessment. To examine Research Question 1, a Pearson's r was calculated to compare math anxiety to achievement.

2. Do high mathematics anxiety middle school students and low mathematics anxiety middle school students differ significantly on mathematics achievement as measured by TCAP?

   The purpose of the question was to discover if low mathematics anxiety students and high mathematics anxiety students differ on mathematics achievement. To examine Research Question 2, an independent *t*-Test was run to determine whether there was a statistically significant difference between low and high mathematics anxiety students.

3. Are there differences among sixth grade, seventh grade, and eighth grade students on math achievement and math anxiety?"

   The purpose of the question was to discover if low mathematics anxiety students score higher on the TCAP assessment. To examine Research Question 3, an ANOVA was run with a Tukey, post-hoc for clarification on factors.

Summary and Conclusion

The process used in Chapter 3 to develop a new instrument to measure math anxiety at the middle school was critical for this study. Middle school students have a smaller attention span compared to other grade levels. With that in mind, the 12-item instrument used in this study was an overall success. The distribution of the math questionnaire went smoothly and the directions were explained with clarity and precision. Chapter 4 will examine the findings of this study and Chapter 5 will discuss the conclusions and recommendations.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

Introduction

The purpose of this quantitative study was to determine the relationship of mathematics anxiety and student achievement at a specific middle school in northern Colorado. Student feelings about mathematics were measured by a 12-item Math Questionnaire (MQ) developed by the researcher. Scarpello (2007) indicated that math anxiety peaks in the middle school which was the major reason this age group was selected. This chapter presents the results of the three specific research questions stated in Chapter 3.

Participants in this study were sixth, seventh, and eighth grade students from one middle school in a mid-sized school district in northern Colorado. Data were used from all students who completed the TCAP assessment from the previous year. Students ranged in age from 11 to 14 years old. Research studies have shown that math anxiety is a detrimental attribution to success in mathematics: "An obvious but unfortunate consequence of the avoidance tendency is that compared with people who do not have math anxiety, highly math-anxious individuals end up with lower math competence and achievement" (Ashcroft, 2002, p. 182). The purpose of this study was to look at math anxiety and how it affects student achievement of sixth, seventh, and eighth grade students attending the researcher's middle school in Colorado. The second purpose was to better understand the issues related to math anxiety so policies and strategies can be implemented to reduce math anxiety.

Study Predictions

Research Question One: What is the association between mathematics anxiety and achievement on TCAP in mathematics? This researcher predicted that the lower achieving

students would have a higher level of math anxiety as measured by the 2012-2013 TCAP assessment and the Math Questionnaire.

Research Question Two: Do high mathematics anxiety middle school students and low mathematics anxiety middle school students differ significantly on math achievement as measured by TCAP? This researcher predicted that students with low mathematics anxiety will score higher on the 2012-2013 TCAP assessment.

Research Question Three: Are there differences among sixth grade, seventh grade, and eighth grade students on mathematics achievement and mathematics anxiety? This researcher predicted that sixth grade students would have a higher level of mathematics anxiety and eighth grade students would have a higher mathematics level of mathematics achievements compared to the other grade levels on the 2012-2013 TCAP assessment.

Data Analysis of Research Questions

The 2013-2014 middle school population consisted of 464 students. Of the 464 students enrolled, only 398 students returned approved consent forms giving an 86% overall return rate for the school. Sixth grade students returned 123 out of 137 students giving them a 90% return rate. Seventh grade students returned 111 out of 137 students giving them an 81% return rate. Eighth grade students returned 164 out of 190 students giving them an 86% return rate. After collecting TCAP scores from the previous year, of the 398 student who returned approved consent forms, only 381 students were selected for the study. Students with no previous year TCAP scores were omitted. Of the 381 student selected, 116 of those were sixth graders, 105 were seventh graders, and 160 were eighth graders. Table 10 shows the frequency and percentages for grade level statistic variables. Table 11 included the total participants by gender for each grade level. A total of 180 females and 201 males were used in this study.

Table 10. *Frequencies and Percents for Grade Level Statistic Variables.*

Variable	N	%
Total Population	381	
6th grade	116	30.4
7th grade	105	27.6
8th grade	160	42.0

Table 11. *Frequencies and Percents for Grade Level Gender Statistic Variables.*

Variable	N	%
6th grade total	116	
Female	69	59.5
Male	47	40.5
7th grade total	105	
Female	48	45.7
Male	57	54.3
8th grade total	160	
Female	63	39.4
Male	97	60.6

Presentation of Results: Research Question 1

The first question was, "What is the association between mathematics anxiety and achievement on TCAP in mathematics?" To investigate if there was a statistically significant association between mathematics anxiety and achievement on TCAP in mathematics, a correlation was computed. Mathematics achievement had a skewness rate of -.735 and mathematics anxiety had a skewness rate of .706, which means parametric assumptions are not violated. A Pearson correlation, a bivariate parametric statistic was used because both variables were approximately normally distributed. Table 12 shows the Pearson's correlation statistic was calculated, $r\,(379) = -.39$, $p=<.001$, which shows a significant relationship. The direction of the correlation was negative, which indicates that students who have high mathematics anxiety tend

to have low mathematics achievement. The r^2 indicates that approximately 15% of the variance in math achievement scores can be predicted from math anxiety scores. Table 13 explains the mathematics achievement scores. At the researcher's middle school 14 students scored unsatisfactory, 64 students scored partially proficient, 140 students scored proficient, and 163 students scored advanced on the mathematics TCAP assessment: 79.5 % of the middle school population scored a combination of proficient and advanced. The descriptors showed that sixth grade had a mean score of (3.18), seventh grade mean score of (3.28), and eighth grade a mean score of (2.99). Meaning that sixth and seventh grade averaged low to medium proficiency on TCAP and eighth grade showed a high partially proficient average on TCAP.

Table 12. *Pearson Statistic Association between Math Anxiety and Math Achievement (N= 381)*

		Correlations	
		Math Achievement	Math Anxiety
Math Achievement	Pearson Correlation	1	-.391
	Sig. (2-tailed)		.000
Math Anxiety	Pearson Correlation	-.391	1
	Sig. (2-tailed)	.000	

Table 13. *Frequency and Descriptive Table of Middle School Math Achievement Scores (N=381)*

Math Achievement Frequency		
	Frequency	Percent
Unsatisfactory	14	3.7
Partially Proficient	64	16.8
Proficient	140	36.7
Advanced	163	42.8
Total	381	100

Math Achievement Descriptive		
	Mean	SD
6th grade	3.38	.74
7th grade	3.28	.81
8th grade	2.99	.89

Presentation of Results: Research Question 2

The second question was, "Do high mathematics anxiety middle school students and low mathematics anxiety middle school students differ significantly on math achievement as measured by TCAP?" In order to examine differences in mathematics achievement between the low math anxiety students and high math anxiety students, an independent samples *t*-test was conducted. Table 14 shows that low math anxiety students were significantly different from high math anxiety students on math achievement ($p \leq .001$). Inspection of the two groups means indicated that the average math achievement score for low math anxiety students (M=3.49) is significantly higher than the score (M=2.66) for high math anxiety students. The difference between the mean is .83 points on the performance index chart for the TCAP test. A 3.49 means low math anxiety students averaged a middle proficient scale score on TCAP compared to a 2.66 means high math anxiety students averaged a middle partially proficient score on TCAP. The effect size d =.91, as indexed by Cohen's (1988) coefficient d was found to exceed the convention for a large effect size (d =.80).

Table 14. *Comparison of low and high math anxiety students on Math Achievement TCAP test (n= 181 low math anxiety and 38 high math anxiety).*

Variable	M	SD	*t*	*df*	*p*	*d*
Math Achievement			6.692	217	.001	.91
Low math anxiety	3.49	.680				
High math anxiety	2.66	.781				

Presentation of Results: Research Question 3

The third question was, "Are there differences among sixth grade, seventh grade, and eighth grade students on math achievement and math anxiety?" The results of the ANOVA found a statistically significant difference in the three grade levels on math achievement, F (2, 378) = 8.41, p = .001, and were not significant on math anxiety, F (2, 378) = 1.70, p = .185. Table 15 indicates that the mean math achievement score in sixth grade was 3.38, in seventh grade was 3.28, and eighth grade was 2.99 meaning sixth and seventh grade students averaged a TCAP performance index of low to medium proficiency scaled score compared to eighth grade averaging a TCAP performance index of high partially proficient scale score. Upon further investigation on math achievement between the groups, the following effect sizes were calculated as indexed by Cohen's (1988) coefficient d: sixth to seventh grade was d = .12 (small effect size d =.20); sixth to eighth grade was d =.35 (slightly more than small but lower than medium d =.50); seventh to eighth was d =.34 (slightly more than small but lower than medium d =.50). Upon further investigation on math anxiety between the groups, the following effect sizes were calculated as indexed by Cohen's (1988) coefficient d: sixth to seventh grade was d =.25 (slightly more than small but lower than medium d =.50); sixth to eighth grade was d =.09 (small effect size d =.20); seventh to eighth was d =.15 (small effect size d =.20).

Table 16 indicates that there is a statistical significance, p = .001, between grade level groups for math achievement. Table 17 Post-Hoc Tukey HSD test indicate that the sixth grade and eighth grade differed in their math achievement scores significantly p =.001. Table 18 Post-Hoc Tukey HSD test indicate no true significance. The biggest significance was between sixth grade and seventh grade in math achievement.

Table 15. *Means and Standard Deviations Comparing Three Grade Levels*

Descriptive Statistics						
	Math Achievement			Math Anxiety		
Grade Level	*n*	*M*	*SD*	*n*	*M*	*SD*
6th grade	116	3.38	.74	116	19.19	6.83
7th grade	105	3.28	.81	105	20.73	5.40
8th grade	160	2.99	.89	160	19.81	6.32
Total	381	3.19	.83	381	19.88	6.26

Table 16. *One-Way Analysis of Variance Summary Table Comparing Three Grade Levels on Math Achievement and Math Anxiety*

Source	SS	*df*	*MD*	*F*	*p*
Math Achievement					
Between groups	11.50	2	5.75	8.41	.000
Within groups	258.28	378	.68		
Total	269.77	380			
Math Anxiety					
Between groups	132.34	2	66.71	1.70	.185
Within groups	14756.11	378	39.04		
Total	14888.45	380			

Table 17. *Post-Hoc Tukey HSD test on the Dependent Variable, Math Achievement*

(I) Grade	(J) Grade	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
6th grade	7th grade	.103	.111	.624	-.16	.37
	8th grade	.392	.101	.000	.15	.63
7th grade	6th grade	-.103	.111	.624	-.37	.16
	8th grade	.289	.104	.016	.04	.53
8th grade	6th grade	-.392	.101	.000	-.63	-.15
	7th grade	-.289	.104	.016	-.53	-.04

Table 18. *Post-Hoc Tukey HSD Test on the Dependent Variables, Math Anxiety*

(I)Elem	(J) Elem	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
6th grade	7th grade	-.154	.841	.160	-3.52	.436
	8th grade	-.629	.761	.687	-2.42	1.16
7th grade	6th grade	1.54	.841	.160	-.436	3.52
	8th grade	.914	.784	.475	-.931	2.76
8th grade	6th grade	.629	.761	.687	-1.16	2.42
	7th grade	-.914	.784	.475	-2.76	.93

Supplemental Findings

As the researcher started collecting student data, curiosity and wonderings began to filter throughout his mind. There were the wonderings around feeder elementary schools, the results of the questionnaire between grade levels, and the difference between females and males at each grade level. These questions fell outside the realm of the four research questions. Below are the results of those wonderings.

Supplemental Findings #1

During the administration of the math questionnaire, students filled in their name, grade, and elementary school on the MQ form. There were three choices for students to write down on the elementary school line. Only two elementary schools feed into the middle school used in this study. Students enter the researcher's middle school either coming from School 1, School 2, or a different school. Other middle schools in the researcher's district have up to five elementary schools feeding into a middle school. School 1 has been recognized as a Colorado Jon Irwin School of Excellence Award winner in previous years. To be recognized as a Jon Irwin School, a school must exceed expectations in the overall school performance frameworks in the areas of

math, reading, writing, and science. School 2 is recognized as a STEM school focusing on Science, Technology, Engineering, and Mathematics.

The researcher ran an ANOVA to answer the following question:

Are there differences between elementary schools on math achievement and math anxiety? The results of the ANOVA were not significant between the three elementary groups on math achievement, F (2, 113) = 2.61, p = .077, and on math anxiety, F (2, 113) = 1.24, p = .291. Table 19 indicates that the mean math achievement score in School 1 was 3.54, the mean achievement score in School 2 was 3.20, and the mean math achievement score in Other was 3.42. The mean math anxiety score in School 1 was 18, the mean math anxiety score in School 2 was 20, and the mean math anxiety score in Other was 20.10. Upon further investigation on math achievement between the groups, the following effect sizes were calculated as indexed by Cohen's (1988) coefficient *d*: School 1 to School 2 was d = .47 (medium effect size d =.50); School 1 to Other was d =.16 (slightly less than small effect size d =.20); School 2 to Other was d =.27 (slightly more than small effect size but lower than medium d =.50). Upon further investigation on math anxiety between the groups, the following effect sizes were calculated as indexed by Cohen's (1988) coefficient *d*: School 1 to School 2 was d = .27 (slightly more than small effect size d =.20); School 1 to Other was d =.37 (medium effect size d =.50); School 2 to Other was d =.01 (small effect size d =.20). Table 20 indicates that there is little statistical significance between grade level groups for math achievement and math anxiety. Table 21 Post-Hoc Tukey HSD test reflects that there was no statistical significance between the elementary schools when comparing math achievement. Table 22 Post-Hoc Tukey HSD test indicated that there was no statistical significance between the elementary schools when comparing math anxiety.

Table 19. *Means and Standard Deviations Comparing Three Elementary School Groups*

Descriptive Statistics						
	Math Achievement			Math Anxiety		
Elementary	*n*	*M*	*SD*	*n*	*M*	*SD*
School 1	48	3.54	.617	48	18.00	6.48
School 2	49	3.20	.790	49	20.00	7.75
Other	19	3.42	.838	19	20.10	4.65
Total	116	3.38	.742	116	19.18	6.83

Table 20. *One-Way Analysis of Variance Summary Table Comparing Three Elementary School Groups on Math Achievement and Math Anxiety*

Source	SS	*df*	MS	F	*p*
Math Achievement					
Between groups	2.803	2	1.401	2.617	.077
Within groups	60.507	113	.535		
Total	63.310	115			
Math Anxiety					
Between groups	116.038	2	58.019	1.248	.291
Within groups	5251.789	113	46.476		
Total	5367.828	115			

Table 21. *Post-Hoc Tukey HSD test on the Dependent Variables, Math Achievement*

(I)Elem	(J) Elem	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
School 1	School 2	.338	.149	.064	-.02	.69
	Other	.121	.198	.816	-.35	.59
School 2	School 1	-.338	.149	.064	-.69	.02
	Other	-.217	.198	.518	-.69	.25
Other	School 1	-.121	.198	.816	-.59	.35
	School 2	.217	.198	.518	-.25	.69

Table 22. *Post-Hoc Tukey HSD test on the Dependent Variables, Math Anxiety*

(I)Elem	(J) Elem	Mean Difference (I-J)	Std. Error	Sig	95% Confidence Interval	
					Lower Bound	Upper Bound
School 1	School 2	-2.00	1.38	.322	-5.28	1.28
	Other	-2.10	1.84	.492	-6.49	2.28
School 2	School 1	2.00	1.38	.322	-1.28	5.28
	Other	-.105	1.84	.998	-4.48	4.27
Other	School 1	2.10	1.84	.492	-2.28	6.49
	School 2	.105	1.84	.998	-4.27	4.48

Supplemental Findings #2

As the researcher was waiting for the first group to finish the questionnaire, he began to wonder about the following questions: #1. What were the individual results of each question by grade level? Was there a mean difference between each question? With this in mind, the researcher explored the idea during analysis of the data.

Upon investigation of the means across grade levels, 7th grade students felt that sometimes their math teacher is helpful in learning mathematics with a mean of (3.82). This is significantly lower than the way sixth grade (4.57) and eighth grade (4.56) felt about their teacher. Question 8, "My parents/guardians have a positive influence on my learning of mathematics" showed that as the grade level increased parents/guardians having a positive influence decreased (6th grade = 4.50, 7th grade = 4.20, 8th grade = 4.01). The researcher had no intention with this wondering to investigate the correlation or variance between the two questions involving teacher and parents. The questions measured parents as an influencer and teacher as being helpful, not measuring a relationship to math anxiety. After further investigation, all other questions fell in the low mathematics anxiety range. The question, "I

have trouble sleeping the night before a math test," had the lowest mean score between the different grade levels.

Table 23. *Variable Properties for Items in the Mathematics Questionnaire (6^{th} grade N = 116, 7^{th} grade N= 105, 8^{th} grade N = 160)*

			M	SD	*Min*	*Max*
1.	When I am in math class, I usually feel nervous	6th grade 7th grade 8th grade	1.88 2.21 2.11	.85 .85 .87	1	5
2.	I worry that other students might understand math problems better than me.	6th grade 7th grade 8th grade	2.37 2.75 2.74	1.12 1.07 1.13	1	5
3.	I feel stressed when I'm about to take a math test.	6th grade 7th grade 8th grade	2.72 2.93 2.80	1.24 1.20 1.17	1	5
4.	I have "butterflies" in my stomach before I go to math class.	6th grade 7th grade 8th grade	1.47 1.46 1.44	.87 .74 .77	1	5
5.	My math teacher is helpful in learning math.	6th grade 7th grade 8th grade	4.57 3.82 4.56	.85 1.10 .62	1	5
6.	I feel frustrated when working on math problems.	6th grade 7th grade 8th grade	2.21 2.72 2.46	.94 .83 .88	1	5
7.	I have trouble sleeping the night before a math test.	6th grade 7th grade 8th grade	1.43 1.29 1.39	.85 .70 .85	1	5
8.	My parents/guardians have a positive influence on my learning of mathematics.	6th grade 7th grade 8th grade	4.50 4.20 4.01	.84 1.02 1.09	1	5
9.	I need extra help in math.	6th grade 7th grade 8th grade	2.17 2.48 2.22	1.12 .92 1.00	1	5
10.	When I need help, I won't ask for help.	6th grade 7th grade 8th grade	2.16 2.24 2.26	1.19 1.03 1.14	1	5
11.	After getting a math test back, I don't want others to see my score.	6th grade 7th grade 8th grade	2.73 2.52 2.43	1.39 1.18 1.21	1	5

12.	I like literacy as much as I like math.	6th grade 7th grade 8th grade	2.55 2.86 2.48	1.33 1.43 1.35	1	5

Note: Students responded to each item using a 5-point Likert scale; 1=never, 2=rarely, 3=sometimes, 4=often, 5=always. Values from 1 to 5 were assigned to each item so that higher scores indicated greater anxiety, excluding questions 5, 8, and 12.

Supplemental Findings #3

A further question emerged during the data analyses and the researcher wondered about the following question? Do male and female students differ significantly in regard to their math achievement and math anxiety scores? An independent sample *t*-test was used to measure the comparison of male and female middle school students on math achievement and math anxiety. Table 25 shows that males were not significantly different from females on math achievement ($p = .5$), and shows that males and females had statistical significance on math anxiety ($p = .013$). Inspection of the two group means indicates that the average math achievement score for males students ($M = 3.16$) is slightly lower than the score ($M = 3.22$) for females. The difference between the means is .06 points on the TCAP assessment. The effect size $d = .07$, as indexed by Cohen's (1988) coefficient *d* was found to be below the convention for a small effect size ($d=.2$) in math achievement. The average math anxiety score for males students ($M = 19.13$) is slightly lower than the score ($M = 20.71$) for females. The difference between the means is 1.58 points on the math anxiety questionnaire. The effect size $d = .25$, as indexed by Cohen's (1988) coefficient *d* was found to be slightly above the convention for a small effect size ($d =.2$) in math anxiety.

Table 24. *Comparison of Male and Female Middle School Students on Math Achievement and Math Anxiety (n=201 males and 180 females)*

Variable	M	SD	*t*	*df*	*p*	*d*
Math Achievement			.66	379	.50	.07
Males	3.16	.89				
Females	3.22	.79				
Math Anxiety			2.49	379	.013	.25
Males	19.13	5.79				
Females	20.71	6.65				

Summary

First, this researcher hypothesized that the lower achieving students have a higher level of math anxiety as measured by the 2012-2013 TCAP assessment and the Math Questionnaire. The results showed that students who have high mathematics anxiety tend to have low mathematics achievement. The hypothesis of the lower achieving students having a higher level of mathematics anxiety was accepted with the understanding that approximately 15% of the variance in mathematic achievement scores can be predicted from mathematics anxiety scores.

Second, this researcher hypothesized that students with low mathematics anxiety would score higher on the 2012-2013 TCAP assessment. The results showed that middle school students with low math anxiety were significantly different from high math anxiety students on math achievement as per TCAP assessments. The findings exceeded the convention for a large effect size. The hypothesis that students with low mathematics anxiety will score higher on the TCAP assessment was accepted.

Thirdly, this researcher hypothesized that students in six grade have less mathematics anxiety than seven grade and seven grade have less mathematics anxiety than eighth grade. The results showed that sixth grade students had less mathematics anxiety than seventh grade

students. Also, the results showed that sixth grade students had less mathematics anxiety than eighth grade students. Surprisingly, seventh grade students had a higher level of mathematics anxiety compared to eighth grade students. The effect size for mathematics anxiety of sixth grade students compared to seventh grade students had a slightly more than small. The effect size of mathematics anxiety of sixth grade students compared to eighth grade students was small. The effect size of mathematics anxiety of seventh grade students compared to eighth grade students was small. The hypothesis for sixth grade having less mathematics anxiety compared to seventh grade and eighth grade is accepted. The hypothesis for seventh grade having less mathematics anxiety compared to eighth grade was rejected.

Finally, this researcher hypothesized that sixth grade students would demonstrate higher levels of mathematics achievement compared to other grade levels as measured by 2012-2013 TCAP assessment. Sixth grade students had a higher mean than the other grade levels in math achievement. The hypothesis for sixth grade having the highest mathematics achievement is accepted.

The supplementary findings were added to help future research in the field of mathematics anxiety mainly focused on sixth, seventh, and eighth grade students. If another researcher chooses to use the math anxiety questionnaire in this study, the researcher can eliminate certain questions or focus a study on a specific question. As a result, the supplementary finding indicated that School 1 had low mathematics anxiety and had a higher level of mathematical achievement compared to School 2. School 2 had high mathematics anxiety with lower mathematics achievement with a small effect size. This information confirmed the hypothesis in which students with low mathematics anxiety will score higher on the TCAP assessment. Secondly, results showed that the variable properties for items in the

mathematics anxiety questionnaire showed that seventh grade students found their mathematics teachers was less helpful compared to sixth and eighth grade. Also, interesting enough was that as the grade level grew, parents/guardians had less positive influences on their student's mathematical learning. Lastly, upon investigation of the differences between female and male students in regard to their mathematics achievement and anxiety, results were thought-provoking. Female students had higher levels of mathematics achievement and had a slightly higher level of mathematics anxiety.

CHAPTER 5: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The overall purpose of this quantitative study was to determine if there was a relationship between mathematics anxiety and mathematics achievement in middle school students. The researcher, who was a former mathematics teacher and current principal, was interested in finding out the barriers standing in the way of learning mathematics at his middle school. With our current educational state of affairs in Colorado, students' academic achievement and academic growth is a priority. A math questionnaire measuring mathematics anxiety was used to determine the level at which middle school students felt about mathematics.

This chapter discusses the results of the three research questions posed in chapter four, discussion of findings related to the literature, supplemental findings, and recommendations for further research are included. The results discussed have different levels of support from the body of literature around mathematics anxiety and mathematics achievement.

Research Questions and Summary of Finding

Research Question One: What is the association between mathematics anxiety and achievement on TCAP in mathematics?

Finding: There was a statistical significance between mathematics anxiety and achievement on TCAP in mathematics. The direction of the correlation was negative, which means that students who have high mathematics anxiety tend to have lower mathematics achievement. Fifteen percent of the variance in math achievement scores can be predicted from mathematics anxiety.

Research Question Two: "Do high mathematics anxiety middle school students and low mathematics anxiety middle school students differ significantly on math achievement as measured by TCAP?"

Finding: The results showed that low math anxiety students were significantly different from high math anxiety students on math achievement with $p = <.001$. The average math achievement score for low math anxiety students (M =3.49) is significantly higher than the score for high math anxiety students (M =2.66).

Research Question Three: "Are there differences among 6th grade, 7th grade, and 8th grade on math achievement and math anxiety?"

Finding: The results showed a statistically significant difference in the three grade level on math achievement with $p = <.001$. Sixth grade had a higher mean score on achievement compared to the other grade levels with (M =3.38) compared to seventh grade (M =3.28) and eighth grade (M =2.99). There was no significance between the three grade levels in math anxiety.

Discussion of Findings Related to the Literature

The first major finding of this research was the significance of a student's mathematics anxiety level determining a student's performance level on mathematics achievement. Low mathematics anxiety students scored higher on mathematics achievement and high mathematics anxiety students scored lower on mathematics achievement. Legg and Lockner (2009) found that mathematical performance did decrease for individuals with higher math anxiety in a study of undergraduates at Georgia Southern University. Furthermore, Luo et al. (2009) investigated mathematics anxiety in middle school students. Their findings are similar and consistent with this study's findings. "The better a student's mathematics performance, the less mathematics

anxiety they may have; the worse a student's performance is, the more mathematics anxiety may have. Thus, mathematics anxiety usually happens among low performing students" (Lou et al. 2009, p.14-15). A study by Hembree (1990) concluded that mathematics anxiety depresses performance meaning higher student achievement resulted in lower mathematics anxiety in middle school students. Numerous studies (Wigfield & Meece, 1988; Ashcraft & Kirk, 2001; Sherman & Wither, 2003) reported similar results as this study. A relationship between mathematics anxiety and mathematics achievement does exist.

Another finding of this research was that sixth grade students had less mathematics anxiety than seventh grade students. Sixth grade students had less mathematics anxiety than eighth grade students. Seventh grade students had a higher level of mathematics anxiety compared to eighth grade students. Birgin et al. (2010) examined the relationship between mathematics anxiety among sixth through eighth grade students in Turkey. The study concluded that sixth grade students had the lowest mathematics anxiety and eighth graders had the highest level of mathematics anxiety. These results do not support the total finding from this current study on middle school students, but are in agreement that sixth grade students had the lowest mathematics anxiety out of the other grade levels. In this study seventh grade students had the highest level of mathematics anxiety compared to the Birgin et al. study which found eighth grade students with the highest level of mathematics anxiety.

Lou et al. (2009) found that seventh grade students had the lowest mathematics anxiety and ninth grade students had the highest level of mathematics anxiety. The seventh grade mathematics anxiety levels are comparatively different but the school experience is the same. Meaning sixth grade is the first year in a middle school and seventh grade is the first year in a

junior high level. So even though the grade levels are different, the grade level of when mathematics anxiety scores are the lowest is similar.

Ma and Xu (2004) through a Longitudinal Study of American Youth (LSAY) of junior high students found that mathematics anxiety began to take shape with eighth grade students. Seventh grade students had the lowest mathematics anxiety of the three grade levels at a junior high school. The results of this study contradict the results in Ma and Xu (2004) study. Seventh grade students at the researcher's middle school had a higher level of mathematics anxiety of the three grade levels. A further investigation for root causes of why seventh grade students had the highest levels of mathematics anxiety is recommended.

Another topic for discussion is the difference of the sixth grade schedule compared to the seventh grade schedule. Unlike a junior-high schedule, the three grade levels have different bell schedules. The only thing in common with the schedule is the beginning of the day and the end of each day. Sixth grade students have 88 minutes of mathematics every day compared to seventh grade only having 70 minutes. The total amount of classes a student takes is the other major difference between the two grade levels. All grade levels are enrolled in mathematics, reading and writing, social studies, science, and PE/health. Sixth grade students only take one semester of science and social studies while seventh and eighth grade take a full year of science and social studies. In other words, sixth grade students have one less class at the middle school compared to seventh and eighth grade students.

The final findings of this research showed that sixth grade student had higher mathematics achievement than seventh grade students and eighth grade students. Eighth grade students had the lowest mathematical achievement score at this middle school. Luo et al. (2009) showed seventh grade students having a higher level of mathematics achievement compared to

eighth grade and ninth grade. Even though the comparison of the researcher's middle school and the studies of junior highs differ, nonetheless, the results are important. The results might point to focusing more on the curriculum and the time that is designated for delivery.

Supplemental Discussion

The first supplemental findings in this research support the overall notion that low mathematics anxiety students perform at a higher mathematical achievement level. Between the two feeder elementary schools to the researcher's middle school, School 1 had low mathematics anxiety and had a higher level of mathematical achievement compared to School 2. School 2 had high mathematics anxiety with lower mathematics achievement. There was no real significance between the groups in math achievement and math anxiety. These results confirm and accept other findings from research on the relationship between mathematics anxiety and mathematics achievement. Fifth grade students in Colorado take the TCAP assessment. The mathematics TCAP assessment contain 54 multiple choice items, which is 56% of the total score points and 15 constructed response items which is 44% of the total score points. Students fall into ranges of unsatisfactory, partially proficient, proficient, and advanced. A deeper issue of the two elementary schools having the equal amount of contact time between students and teachers, and yet there are discrepancies. The two schools also use the same district approved mathematics curriculum, making the differences unusual. Exploring further differences at the two feeder schools could help with math teachers, math curriculum coordinator, counselor, and administration team focus on more collaboration with both elementary feeder schools. Understanding the different instructional strategies and pedagogy will help develop stronger mathematic students. Further research needs to be done to discover specific differences between the two schools that could impact math anxiety and achievement. Topics for inquiry could be

around schedules, interventions, curriculum, after school programs and the way students get assistance.

The second supplemental finding in this research may support why seventh grade students at the researcher's middle school showed higher levels of mathematics anxiety compared to other students. Seventh grade students felt that sometimes their math teacher was helpful in learning of mathematics. This result was different than sixth and eighth grade reporting that often their math teacher was helpful in the learning of mathematics. These finding would raise questions at the researcher's middle school of why seventh grade students felt that their teacher was less helpful compared to sixth and seventh grade students.

The last supplemental finding of this study found that female students slightly outperformed male students on mathematical achievement as measured by 2012-2013 TCAP testing. The average math anxiety score as measured by the mathematics questionnaire for female students was slightly higher than the score for male students. The results of this study indicate female students at the researcher's middle school outperformed male students and had higher levels of mathematics anxiety. More study is needed in this area to further explore gender differences in math anxiety.

Implications for Practice

Upon careful analysis of the data from this study, it is clear there is a significant relationship between mathematics anxiety and mathematics achievement. Within the context of this middle school, findings could help inform the next steps for improving student achievement and student growth in mathematics. Recommendations for curricular support will assist in meeting school goals and improve student learning. Recommendations are as follows:

1. A study could be conducted to understand why seventh grade students had a higher level of mathematics anxiety compared to the other grade levels at the researcher's middle school. A comparative study may involve other seventh grade students in the Thompson School District to find out similarities and differences amongst the different schools. A further look into instructional pedagogy at the different schools may explain shortcomings. A focus of the study would be to explore into the structure of the classrooms and how students learn mathematics as a whole.
2. An intervention program could be developed to address students with high levels of mathematics anxiety. The program would build the confidence in student's mathematical ability and help reduce their negative attitudes towards mathematics. The six week intervention program would start off with students discussing their previous experiences of learning mathematics. Whether positive or negative, this self-talk would help build confidence or self-efficacy (Stevens et al., 2009) in the students' mathematics ability increasing academic performance. These unsuccessful experiences with math during middle school years may cause students to doubt their mathematical ability, purposefully withdraw effort, and underperform in mathematics (Turner et al., 2002; Scarpello, 2007). The outcome of the program could be to change the attitude towards mathematics of students to help in their regular math class.
3. Professional development could be provided to classroom teachers to implement instructional strategies that are proven to reduce mathematics anxiety with students. Using a constructivist approach in a reformed mathematical classroom would improve retaining mathematics compared to the traditional classroom of memorizing algorithms, student desks in a straight row, and the teacher doing all the work. The second

professional learning for teachers could be teaching proper organizational strategies to students, learn motivational techniques for students, help teachers establish procedures, and develop common planning time with other mathematics teachers

4. Students could take the math questionnaire at the end of the school year to measure their levels of mathematics anxiety to be placed in an intervention program for the following year. The current schedule at the researcher's middle school has a 40-minute intervention class at the end of the school day which would provide the opportunity for students with high mathematics anxiety to have more access to mathematics at the end of the day.
5. A parent/guardian class could be offered to the families of students who have high mathematics anxiety. The curriculum for this class should include techniques to reduce mathematics anxiety at home and show parents tips on how to help their students in mathematics. Boaler (2008) explained that the best thing parents can do to help their children in mathematics interest is to explore mathematical patterns, ideas, and provide mathematical settings. It's not about giving more math work but more of encouraging and validating their student's mathematical thinking.
6. Classroom cultures should reflect Davis (2012) Math Anxiety Bill of Rights. The following statements would help decrease mathematics anxiety by exposing students to a culture and climate of redefining mathematical success:
    a. I have the right to ask whatever questions I have.
    b. I have the right to need extra help.
    c. I have the right not to understand.
    d. I have the right to feel good about myself regardless of my abilities in math.
    e. I have the right to relax.

f. I have the right to dislike math.

Recommendations for Further Research

The findings of this study suggest the following recommendations for future research:

1. Results of this study could be used by researchers to plan further studies around mathematics anxiety and mathematics achievement at different middle schools around the state of Colorado. Extensive research at the middle school level in U.S. schools is missing in current research.
2. Further investigations starting with elementary aged students need to be assessed to understand exactly when mathematics anxiety occurs.
3. In order to understand teaching practices, a study should be done on traditional and non-traditional teaching practices and their effects on student's mathematical achievement and mathematical anxiety.
4. Ashcraft and Kirk (2001) suggested that individuals with high math anxiety take fewer math courses, a future study should be done to see the relevancy of this concept.
5. A qualitative study such as interviews with teachers, principals, counselors, parents, and with participants may lead to better understanding of the relationship between mathematics anxiety and mathematics achievement.
6. A further study on current student data examining mathematics anxiety between female and male middle school students.
7. A study examining the culture and climate of math classrooms and how teachers are teaching mathematical concepts and their effects on mathematics anxiety of the students.

Discussion on Reducing Math Anxiety

Math anxiety like other phobias is a condition that people deal with daily. The first step in helping students overcome math anxiety is to identify which students experience a high level of math anxiety. From there, educators can select the appropriate instructional strategies to decrease math anxiety or change the classroom environment. Tobias (1993) explained that success depends on the treatment being used. Math teachers need to spend time during a class period to discuss student feelings. "People who don't like math don't like to talk about math" (Tobias, 1993, p. 240). Unfortunately math exists beyond the classroom and talking about it helps students understand math doesn't go away.

A high school in New York implemented a "math clinic" in which students attended the class once a week to meet with math therapists. Math was not taught at the beginning of the math clinic. Rather the students talked about their feelings about math. "At first, the teacher was afraid that her class would fall behind because her students were missing one-third of their lessons. Soon she discovered, however, that her students were progressing more rapidly" (p. 240).

Concluding Remarks

In conclusion, Ashcraft and Kirk (2001) stated one important fact. "Individuals with high math anxiety take fewer math courses, earn lower grades in the classes they do take, and demonstrate lower math achievement and aptitude than their counterparts with low math anxiety" (p. 224). The findings in this study show that past trends are continuing without any change.

As an individual in the educational profession, opening the doors of success for students in mathematics is important and imperative. Mathematics anxiety has never been a topic of

discussion in schools. I hope this research will start discussions around the barriers of mathematics anxiety and help students achieve their hopes and dreams. The issue is real. Being a parent of a teenager who struggles with mathematics is a helpless feeling. Schools need to explore research around this topic and open their mind to the notion that teachers, parents, and classroom environments are partially responsible for developing mathematics anxiety in the youth of tomorrow.

REFERENCES

Adelson, J. L., & McCoach, D. (2011). Development and psychometric properties of the math and me survey: Measuring third through sixth graders' attitudes toward mathematics. *Measurement & Evaluation in Counseling & Development, 44*(4), 225-247.

Alsup, J. (2005). A comparison of constructivist and traditional instruction in mathematics. *Educational Research Quarterly, 28*(4), 3-17.

American Psychological Association (2014). *Anxiety.* Retrieved from http://www.apa.org/topics/anxiety/index.aspx

An, S. (2004). *The middle path in math instruction: Solutions for improving math education*. Lanham, MD: Scarecrow Education.

Arnold, D. H., Fisher, P. H., Doctoroff, G. L., & Dobbs, J. (2002). Accelerating math development in Head Start classrooms. *Journal of Educational Psychology, 94*(4), 762-770.

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

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

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

Baloğlu, M., & Balgalmiş, E. (2010). The adaptation of the mathematics anxiety rating scale-elementary form into Turkish, language validity, and preliminary psychometric investigation. *Educational Sciences: Theory & Practice, 10*(1), 101-110.

Begley, S. (2012). Anything boys can do. *Scientific American, 306*(1), 25.

Beilock, S. L. (2008). Math performance in stressful situations. *Current Directions in Psychological Science, 17*(5), 339-343.

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

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

Birgin, O., Baloğlu, M., Çatlıoğlu, H., & Gürbüz, R. (2010). An investigation of mathematics anxiety among sixth through eighth grade students in Turkey. *Learning & Individual Differences, 20*(6), 654-658.

Boaler, J. (2008). *What's math got to do with it?: Helping children learn to love their most*

Cheema, J. R., & Galluzzo, G. (2013). Analyzing the gender gap in math achievement: Evidence from a large-scale US sample. *Research in Education, 90*, 98-112.

Colorado Department of Education. (2014). *Colorado NAEP testing.* Retrieved from http:www.cde.state.co.us/assessment/conaep

Colorado Department of Education. (2015). *TCAP/CSAP frameworks and fact sheets*. Retrieved from http://www.cde.state.co.us/assessment/coassess-frameworksandfactsheets

Davis, S. (2012). *Math Anxiety Bill of Rights.* Retrieved from http://faculty.mc3.edu/cvaughen/mathconfidence/rights.htm

Demanet, J., & Van Houtte, M. (2012). Teachers' attitudes and students' opposition. School misconduct as a reaction to teachers' diminished effort and affect. *Teaching & Teacher Education, 28*(6), 860-869.

Dreger, R. M, & Aiken, L. R. (1957). Identification of number anxiety. *Journal of Educational Psychology, 47*, 344-351.

Elias, M. J., & Bruene Butler, L. (2005). *Social decision making/social problem solving for middle school students: Skills and activities for academic, social, and emotional success.* Champaign, IL.: Research Press.

Engelhard Jr., G. (1990). Math anxiety, mother's education, and the mathematics performance of adolescent boys and girls: Evidence from the United States and Thailand. *Journal of Psychology, 124*(3), 289.

Falco, L. D., Summers, J. J., & Bauman, S. (2010). Encouraging mathematics participation through improved self-efficacy: a school counseling outcomes study. *Educational Research & Evaluation, 16*(6), 529-549.

Fast, L. A., Lewis, J. L., Bryant, M. J., Bocian, K. A., Cardullo, R. A., Rettig, M., & Hammond, K. A. (2010). Does math self-efficacy mediate the effect of the perceived classroom environment on standardized math test performance?. *Journal of Educational Psychology, 102*(3), 729-740.

Furner, J. M., & Gonzalez-DeHass, A. (2011). How do students' mastery and performance goals relate to math anxiety?. *EURASIA Journal of Mathematics, Science & Technology Education, 7*(4), 227-242.

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

Gliner, J. A., & Morgan, G. A. (2009). *Research methods in applied settings: An integrated approach to design and analysis,* (2nd ed.). New York, NY: Routledge.

Gough, M. F. (1954). Mathemaphobia: Causes and treatments. *Clearing House, 28*, 290-294.

Gunderson, E., Ramirez, G., Levine, S., & Beilock, S. (2012). New directions for research on the role of parents and teachers in the development of gender-related math attitudes: Response to commentaries. *Sex Roles, 66*(3/4), 191-196.

Hall, C. W., Davis, N. B., Bolen, L. M., & Chia, R. (1999). Gender and racial differences in mathematical performance. *Journal of Social Psychology, 139*(6), 677-689.

Hanchon, T. A. (2011). Examining perfectionism through the lens of achievement goal theory. *North American Journal of Psychology, 13*(3), 469-490.

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

Jacobs, J. E. (1991). Influence of gender stereotypes on parent and child mathematics attitudes. *Journal of Educational Psychology, 83,* 518–527.

Kesici, Ş., & ErdoĞan, A. (2010). Mathematics anxiety according to middle school students' achievement motivation and social comparison. *Education, 131*(1), 54-63.

Latterell, C. M. (2005). *Math wars: A guide for parents and teachers.* Westport, CT.: Praeger.

Legg, A. M., & Locker Jr., L. (2009). Math performance and its relationship to math anxiety and metacognition. *North American Journal of Psychology, 11*(3), 471-485.

Levine, M. (2002). *A mind at a time.* New York, NY: Simon & Schuster.

Lou, X., Wang, F., & Lou, Z. (2009). Investigation and analysis of mathematics anxiety in middle school students. *Journal of Mathematics Education, 12*(2). 12-19.

Ma, X. X., & Xu, J. (2004). Erratum to "the causal ordering of mathematics anxiety and mathematics achievement: A longitudinal panel analysis" *Journal of Adolescence, 27*(3), 379.

Meece, J. L., & Wigfield A., & Eccles, J. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*(1), 60-70.

Metsämuuronen, J. (2012). Comparison of mental structures of eighth-graders in different countries on the basis of Fennema-Sherman test. *International Journal of Psychological Studies, 4*(4), 1-17.

Morgan, G. A., Leech, N., Gloeckner, G., Barrett, K. (2011). *IBM SPSS for introductory statistics: Use and interpretation, (4th ed.).* New York, NY: Brunner-Routledge.

Nist, & Diehl. (2014). *Test Anxiety Questionnaire.* Retrieved from http://web.ccsu.edu/fye/teachingresources/pdfs/test%20anxiety%20questionnaire.pdf

O'Conner, K. (1997). *A repair kit for grading: 15 fixes for broken grades.* Boston, MA: Pearson Education.

OECD (2010), PISA 2009 Results: What students know and can do. *Student Performance in Reading, Mathematics and Science, 1*(1).

Orton, A. (1994). *Issues in teaching mathematics*. London, UK: Cassell.

Pajares, F. & Miller, D. (1995). Mathematics self-efficacy and mathematics performances: The need for specificity of assessment. *Journal of Counseling Psychology, 42*(2), 190-198.

Peters Mayer, D. (2008). *Overcoming school anxiety: How to help your child deal with separation, tests, homework, bullies, math phobia, and other worries.* New York, NY: AMACOM, American Management Association.

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition & Development, 14*(2), 187-202.

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

Ruffins, P. (2007, March 8). A real fear. Retrieved from http://diverseeducation.com/article/7085/

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

Schoenfeld, A. H. (2007). *Assessing mathematical proficiency*. Cambridge UK: Cambridge University Press.

Secada, W. G. (1995). *New directions for equity in mathematics education*. Cambridge UK: Cambridge University Press.

Sharpe, E. (2012). Growing our graduates. *Biologist, 59*(1), 13.

Sherman, B., & Wither, D. (2003). Mathematics anxiety and mathematics achievement. *Mathematics Education Research Journal, 15*(2), 138-150.

Smith, F. (2002). *The glass wall: Why mathematics can seem difficult*. New York, NY: Teachers College Press.

Sparks, S. P. (2011). Brain imaging provides clues on math anxiety. *Education Week, 31*(9), 5.

Speilberger, C. D. (1995). *Test anxiety: theory, assessment, and treatment*. Washington, DC: Taylor & Francis.

Stevens, T. T., Harris, G. G., Aguirre-Munoz, Z. Z., & Cobbs, L. L. (2009). A case study approach to increasing teachers' mathematics knowledge for teaching and strategies for building students' maths self-efficacy. *International Journal of Mathematical Education in Science & Technology, 40*(7), 903-914.

Suinn, R. M., Edie, C. A., Nicoletti, J., & Spinelli, P. (1972). The MARS, a measure of mathematics anxiety: Psychometric data. *Journal of Clinical Psychology, 28*(3), 373-375.

Suinn, R. M., & Edwards, R. (1982). The measurement of mathematics anxiety: The mathematics anxiety rating scale for adolescents MARS-A. *Journal of Clinical Psychology, 38*(3), 576-580.

Tobias, S. (1993). *Overcoming math anxiety*, (Rev. and expanded.). New York, NY: W.W. Norton.

Tomlinson, C. A., & Imbeau, M. B. (2010). *Leading and managing a differentiated classroom.* Alexandria, VA.: ASCD.

Turner, J. C., Midgley, C., Meyer, D. K., Gheen, M., Anderman, E. M., Kang, Y., & Patrick, H. (2002). The classroom environment and students' reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology, 94*(1), 88-106.

Tyrer, P. J. (1999). *Anxiety: A multidisciplinary review.* London: Imperial College Press.

Watson, A. (2006). *Raising achievement in secondary mathematics.* Maidenhead: Open University Press.

Whitaker, M., & Dempsey, K. (2013). School influences on parents' role beliefs. *Elementary School Journal, 114*(1), 73-99.

Wigfield, A., & Meece, J. L. (1988). Math anxiety in elementary and secondary school students. *Journal of Educational Psychology, 80*(2), 210-16.

Wormeli, R. (2007). *Differentiation: From planning to practice, grades 6-12.* Portland, ME.: Stenhouse.

Yeo, D. (2003). *Dyslexia, dyspraxia and mathematics.* London UK: Whurr.

APPENDIX A

Meece Math Anxiety Questionnaire Items

1. When the teacher says he/she is going to ask you some questions to find out how much you know about math, how much do you worry that you will do poorly? *{not at all, very much)*

2. When the teacher is showing the class how to do a problem, how much do you worry that other students might understand the problem better than you? *(not at all, very much)*

3. When I am in math, I usually feel *(not at all at ease and relaxed, very much at ease and relaxed).*

4. When I am taking math tests, I usually feel *(not at all nervous and uneasy, very nervous and uneasy).*

5. Taking math tests scares me. (/ *never feel this way, I very often feel this way)*

6. I dread having to do math. (/ *never feel this way, I very often feel this way)*

7. It scares me to think that I will be taking advanced high school math, *(not at all, very much)*

8. In general, how much do you worry about how well you are doing in school? *(not at all, very much)*

9. If you are absent from school and you miss a math assignment, how much do you worry that you will be behind the other students when you come back to school? *(not at all very much)*

10. In general, how much do you worry about how well you are doing in math? *(not at all, very much)*

11. Compared to other subjects, how much do you worry about how well you are doing in math? *(much less than other subjects, much more than other subjects)*

APPENDIX B

Revised Math Anxiety Questionnaire

Directions: Indicate how often each statement describes you by circling only one of the five terms next to the statement.

1.	When I am in math class, I usually feel nervous	Never	Rarely	Sometimes	Often	Always
2.	I worry that other students might understand math problems better than me.	Never	Rarely	Sometimes	Often	Always
3.	I feel stressed when I'm about to take a math test.	Never	Rarely	Sometimes	Often	Always
4.	I have "butterflies" in my stomach before I go to math class.	Never	Rarely	Sometimes	Often	Always
5.	Being called on to answer a math question scares me.	Never	Rarely	Sometimes	Often	Always
6.	I feel frustrated when working on math problems.	Never	Rarely	Sometimes	Often	Always
7.	I have trouble sleeping the night before a math test.	Never	Rarely	Sometimes	Often	Always
8.	I avoid my math homework.	Never	Rarely	Sometimes	Often	Always
9.	I need extra help in math	Never	Rarely	Sometimes	Often	Always
10.	When I need help, I won't ask for help.	Never	Rarely	Sometimes	Often	Always
11.	After getting a math test back, I don't want others to see my score.	Never	Rarely	Sometimes	Often	Always
12.	I've said "I hated math" this year.	Never	Rarely	Sometimes	Often	Always

APPENDIX C

Math Questionnaire

Name: _____ Grade: _____ Elementary: _____

Directions: Indicate how often each statement describes you by circling only one of the five terms next to the statement.

1.	When I am in math class, I usually feel nervous	Never	Rarely	Sometimes	Often	Always
2.	I worry that other students might understand math problems better than me.	Never	Rarely	Sometimes	Often	Always
3.	I feel stressed when I'm about to take a math test.	Never	Rarely	Sometimes	Often	Always
4.	I have "butterflies" in my stomach before I go to math class.	Never	Rarely	Sometimes	Often	Always
5.	My math teacher is helpful in learning math.	Never	Rarely	Sometimes	Often	Always
6.	I feel frustrated when working on math problems.	Never	Rarely	Sometimes	Often	Always
7.	I have trouble sleeping the night before a math test.	Never	Rarely	Sometimes	Often	Always
8.	My parents/guardians have a positive influence on my learning of mathematics.	Never	Rarely	Sometimes	Often	Always
9.	I need extra help in math.	Never	Rarely	Sometimes	Often	Always
10.	When I need help, I won't ask for help.	Never	Rarely	Sometimes	Often	Always
11.	After getting a math test back, I don't want others to see my score.	Never	Rarely	Sometimes	Often	Always
12.	I like literacy as much as I like math.	Never	Rarely	Sometimes	Often	Always

APPENDIX D

Consent to Participate in a Research Study

Colorado State University

Hello Parents/Guardians:

As your principal of Turner Middle School, I have been working on my Ph.D. for the past several years through the Colorado State University School of Education. Under the guidance of my advisor, Donna Cooner, Ph.D., I am conducting research to find a correlation between math anxiety and student achievement. The results from my study could help change the way we help students experience success in mathematics. I'm asking for permission for your student to be involved in the study. All information from this study will be confidential and I'm the only researcher involved. Students will be given a 12-item questionnaire asking questions around math anxiety. Below is more information about my research. If you give your child permission to participate, please sign and return this form to school by _____.

TITLE OF STUDY: *The correlation between math anxiety and student achievement.*

PRINCIPAL INVESTIGATOR: *Donna Cooner, Ph.D., Director, 491-5292*

CO-PRINCIPAL INVESTIGATOR: *Mr. Siebers, Doctoral Student, 613-7403*

WHY AM I BEING INVITED TO TAKE PART IN THIS RESEARCH? *The study is focused on 6th, 7th, and 8th grade students. Mr. Siebers is a former math teacher and curious on how math anxiety effects student achievement.*

WHO IS DOING THE STUDY? *Mr. Siebers, CSU Doctoral Student and principal of Turner Middle School*

WHAT IS THE PURPOSE OF THIS STUDY? *The purpose is to investigate if there is a relationship between math anxiety and math student achievement.*

WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST? *The study will take place during your child's normal school day. The survey will take no more than 5 minutes.*

WHAT WILL YOUR STUDENT BE ASKED TO DO? *Each student will have a few minutes to fill out a math anxiety questionnaire during their math class. The researchers are also asking your consent to match this survey to your student's TCAP math scores. Participation in this research will have no effect on your child's class grade and the survey responses will not be included in student records.*

ARE THERE REASONS WHY I SHOULD NOT TAKE PART IN THIS STUDY? *There is no reason for your child not to be a part of the study. All information is confidential and no student names will be used in the write-up.*
WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS? *It is not possible to identify all potential risks in research procedures, but the researcher has taken reasonable safeguards to minimize any known and potential, but unknown, risks.*

ARE THERE ANY BENEFITS TO TAKING PART IN THE STUDY? There are no known direct benefits to your child; however, the results from my study may help change the way we help students experience success in mathematics.

DO I HAVE TO TAKE PART IN THE STUDY? *Your child's participation in this research is voluntary. If you or your child decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.*

WHO WILL SEE THE INFORMATION THAT I GIVE? We will keep private all research records that identify your child.

Your child's information will be combined with information from other students taking part in the study. Once your child's TCAP scores have been matched to his/her survey results all names will be removed from the data. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. Your child will not be identified in these written materials. We may publish the results of this study; however, we will keep your child's name and other identifying information private.

WHAT IF I HAVE QUESTIONS? *Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions about the study, you can contact the investigator, Mr. Bill Siebers at 613-7403. If you have any questions about your rights as a volunteer in this research, contact Janell Barker, Human Research Administrator at 970-491-1655.*

This consent form was approved by the CSU Institutional Review Board for the protection of human subjects in research.

Your signature acknowledges that you have read the information stated and willingly sign this consent form. Your signature also acknowledges that you have received, on the date signed, a copy of this document containing 3 pages.

_____ _____
Signature of person agreeing to take part in the study Date

_____
Printed name of person agreeing to take part in the study

_____ _____
Name of person providing information to participant Date

_____
Signature of Research Staff

PARENTAL SIGNATURE FOR MINOR

As parent or guardian I authorize _____ (print name) to become a participant for the described research. The nature and general purpose of the project have been satisfactorily explained to me by _____ and I am satisfied that proper precautions will be observed.

_____
Minor's date of birth

_____
Parent/Guardian name (printed)

_____ _____
Parent/Guardian signature Date

APPENDIX E

Student Assent Form

Colorado State University Application for Human Research Review:

Model Assent for Children

Hi!

You know me as your Principal, but I am also a student researcher at Colorado State University in the School of Education. My research is about the connection between your feelings and how well you do in math. We are hoping to help students do better in math in the future. I am asking you to take a 12-question survey that I will match with your TCAP scores.

If you say it is OK, I'll ask you to take the survey during today's class. It will ask questions about how you feel about math. There isn't a right or wrong answer --- it is just about what you think. It will take about 5 minutes. Your name will be on the survey, but once the survey is matched with your TCAP scores, I will take your name off of the survey and I won't know how you answered or what you did.

Agreeing to be in this project cannot hurt you. It won't help you, either. You won't get any gift for doing it. You don't have to do it. If you say "yes" now but later change your mind, you can stop being in the research any time by just telling me.

I have asked your parents if it is OK that you do this, too. If you want to be in this research, sign your name and write today's date on the line below.

_____ _____

Student Date

_____ _____

Researcher Date

APPENDIX F

Math Anxiety Questionnaire

Script

Hello Class! I'm here today to ask you to participate in a math questionnaire to complete. This questionnaire is part of my doctoral study around mathematics and how to help students become more successful at math. Being a former math teacher before becoming your principal, it has always been a passion of mine to help students in mathematics. The questionnaire you are about to receive consists of twelve statements about your feelings about math.

Distribute the math questionnaire to each student.

Make sure each student has a pen or pencil and a math questionnaire is in front of them.

Please take a look at the questionnaire in front of you. Please read the directions as I read them aloud. Directions: Indicate how often each statement describes you by choosing a number from one to five as outlined below. There are five choices; never, rarely, sometimes, often, and always. After reading each statement, clearly circle your selection. This questionnaire is important to my study and please answers each statement honestly. After you complete the questionnaire, please put your pencil down and turn your sheet over. Are there any questions? You may begin.