GENDER DIFFERENCES IN FACTORS PERTAINING TO MATH ANXIETY AMONG COLLEGE STUDENTS

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GENDER DIFFERENCES IN FACTORS PERTAINING TO MATH ANXIETY AMONG COLLEGE STUDENTS

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ABSTRACT

Math anxiety has been seen as one of the biggest obstacles to student success in mathematics. The nature of this condition, as well as its relationships with numerous predictors, has been investigated for decades. However, there is still a significant lack of agreement among the findings of these research studies. The current study examines gender differences in relationships between age, time without mathematics, math preparedness level, student perceptions of teachers’ and parents’ attitudes toward this discipline, and math anxiety. The corresponding relationships are also investigated for two major dimensions of this condition: numerical anxiety and math test anxiety.

The results of this study indicate that impact of the proposed predictors on math anxiety vary based on gender. It further suggests that the structure and nature of this condition are different for female and male students.
DEDICATION

“Whatever our souls are made of,
    his and mine are the same…”

    Emily Bronte

To my love, my husband Joe.
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CHAPTER I

INTRODUCTION

Background of Math Anxiety

To truly overcome the obstacles in our academic endeavors, we need to be able to fully identify, understand, and accept them. In today’s technological and scientific society, importance of mathematics is highly accentuated. However, in spite of its significance, there is still a high number of students who shy away from “math heavy” courses and terminate certain career paths without ever even embarking on them. One of the biggest hurdles many students face in their academic careers is mathematics, a discipline that is intertwined in almost every natural and social science, as well as many health and business related fields. Fears related to this fundamental area of study continue to be seen as a major cause for not pursuing academic goals which rely heavily on mathematics, therefore minimizing vocational opportunities
for individuals harboring these feelings of anxiety. Such feelings are what have led to what is commonly referred to as “math anxiety”.

As a result of such views, math anxiety is often the reason used for the poor performance of a wide range of individuals in settings where math-related skills are essential. Math anxiety does not have a unique description, but rather it has been described using various descriptions. For example, Tobias (1978) describes it as "sudden death" (p. 46). Kogelman and Warren (1979) refer to it simply as an adverse reaction to mathematics, while Byrd (1982) says it is the feeling of anxiety "when confronted with mathematics in any way" (p. 38). Richardson and Suinn (1972) state that math anxiety "involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson and Suinn, 1972, p.551).

The range of descriptions mentioned above comes about because math anxiety is a broad term used by many individuals to cover a wide range of observed characteristics of students. For example, some use it to
describe the supposed cause of physiological symptoms when encountering math, such as sweaty palms, nausea, heart palpitations, a hot tingling feeling, stomach aches or stomach cramps, and/or tightening muscles (Godbey, 1997; Perry, 2004). Others use this term to classify psychological symptoms that manifest in situations involving mathematical tasks. These symptoms include difficulty thinking, extreme nervousness, an inability to focus on the instructor, difficulty concentrating, negative self-talk, and/or a general sense of uneasiness (Ashcraft & Kirk, 2001; Godbey, 1997; Perry, 2004). Some individuals evidence a mixture of these characteristics.

Furthermore, many researchers believe that test anxiety, which is defined as “an otherwise confident student’s state of panic during a test where self-doubt leads to a failure to realize potential in a testing environment” (Perry, 2004, p. 321) is closely related to and/or a component of math anxiety. As has been done in the literature, the use of “math anxiety” in this work will be applied to individuals who evidence the type of responses and characteristics discussed above when they are engaged in math related activities.
As reported by Perry (2004), up to 85% of college students taking an introductory mathematics course feel at least mild math anxiety. In the last decade or so, research has begun to focus on cognition with respect to math anxiety and its impact on individuals. Ashcraft and Kirk found that math anxiety interferes with activities of working memory by degrading its accuracy, which in turn negatively affects performance (2001). As a result, the impacts can be pervasive and overwhelming for those individuals with extreme cases of math anxiety.

Determining the cause of math anxiety is extremely complex. Some of the possible causes include “inability to handle frustration, excessive school absences, poor self-concept, parental and teacher attitudes toward mathematics, and emphasis on learning mathematics through drill without understanding” (Norwood, 1994, p. 250). “An extremely common occurrence is the following: a student has a superficial understanding of mathematics limited to computational skills, with little conceptual understanding and hence no mental framework within which to organize his/her knowledge. As a result, this type of student forgets what he or she learns very quickly and experiences
chronic frustration” (Perry, 2004, p. 323). Such a situation leads to symptoms that are often characterized as math anxiety, thereby forming a negative feedback loop. Poor understanding of math materials causes math anxiety, which in turn leads to difficulty learning and mastering conception, and finally this malady results in poor understanding of these concepts.

**Purpose of the Study**

The purpose of this study is to explore gender differences in math anxiety. More specifically, this study will investigate if age, math achievement scores, time passed since the last mathematics course, and perceived parent and teacher attitudes toward mathematics impact the effects of gender on math anxiety, and if so, determine if those impacts are same for males and females.

**Impact of Math Anxiety on Math Performance**

Students, who supposedly suffer from this form of anxiety, believe that math anxiety is detrimental to their performance in mathematics courses. Based on anecdotal
evidence, this is believed to be one of the most common reasons for students opting for majors that traditionally do not require a strong mathematics background. However, in today’s society, this means that due to their anxiety related to mathematics, these students are self limiting their options so that some of the most in-demand careers and future employment opportunities are no longer open to them. Tobias (1978) sees math anxiety as an obstruction for realizing students’ academic goals. “And nothing changes the fact that math avoidance is extremely limiting for people at all levels of work. Competence in math is, ... truly a vocational filter” (Tobias, 1978, p.29). Therefore, understanding the nature of this phenomenon and its relationship with various factors is essential for the creation of successful treatments for minimizing the damaging effects math anxiety has on people who suffer from it.

But does math anxiety have an effect on student performance in math courses? And if it does, what is the nature of that effect? The beliefs about the influence of math anxiety on math performance vary among researchers. While there are many who believe that math anxiety has a
detrimental effect on students’ academic success in mathematics courses, there are others whose research findings oppose these beliefs. Disagreement begins with the very nature of math anxiety and its relationship with test anxiety. Hunsley (1987) explored the functional similarities and differences in the cognitive processes that take place in math and test anxious students. The results of this study confirmed the prior research findings where math anxiety and test anxiety were found to be highly correlated. It also indicated that both forms of anxiety were associated with lower grade prediction and lower level of preparedness among the students. Additionally, students experiencing higher levels of math anxiety and test anxiety had more frequent negative internal dialogue and they saw math ability and exam difficulty as hindrances to exam performance.

The view supporting the existence of a negative relationship between math anxiety and math performance is also present in the literature. Number anxiety, identified by Dreger and Aiken (1957), was correlated negatively with grades in math courses, indicating that a form of anxiety, separate from test anxiety, was affecting students’ math
performance. The effects of math anxiety on math performance may be influenced by students’ math ability. Resnick, Viehe, and Segal (1982) report that students in higher level math courses had less math anxiety than students in the lower ones. This supports the belief that math ability affects the level of math anxiety, which indirectly influences math performance. Furthermore, Morris, Kellaway, and Smith (1978) reported that math anxiety seemed to negatively affect psychology students’ (enrolled in introductory statistics course) math performance, while the performance of mathematics students (enrolled in sophomore-junior level math courses) seemed to be unaffected by their math anxiety level. It is important to note that the mathematics students had lower levels of math anxiety than their psychology counterparts, which further supports the hypothesized existence of a relationship between math ability, math performance, and math anxiety.

Impact of Math Anxiety on Teachers

Teachers’ beliefs and attitudes toward mathematics have a significant impact on their teaching practices.
Therefore, understanding the causes underlying these beliefs and any resulting math avoidance behavior is crucial in order to ensure positive teaching and learning experiences for both teachers and their students (Uusimaki & Nason, 2004). Furthermore, research shows that teacher beliefs play a major role in their students’ achievement; hence any conditions, such as math anxiety, that may negatively affect these beliefs are vital in the mathematical learning of students. Consciously or not, teachers with high levels of math anxiety pass those feelings of tension and discomfort, as well as math avoidance behaviors, to their students (Wood, 1988).

Presence of math anxiety is evident among many college students. However, pre-service teachers report higher levels of math anxiety than other undergraduate students (Hembree, 1990). For that reason, understanding math anxiety and being able to identify causal relationships between this phenomenon and several of its predictors will have a powerful impact on not only the general student population, but also on pre-service teachers and consequently, the quality of future mathematics instruction.
Assumptions Underlying the Study

Several assumptions underlie this study.

1. The instrument that will be used to measure math anxiety, the Math Anxiety Rating Scale Brief (MARS-Brief), is assumed to be a valid and reliable assessment tool. This assumption is based on the psychometric evidence presented in the literature.

2. The demographic questionnaire administered to participants is a valid and reliable measure.

3. The participants’ responses on the MARS-Brief are assumed to be truthful and accurate.

4. The participants’ responses on the demographical questionnaire are assumed to be truthful and accurate.

Definitions and Operational Terms

In order to ensure clarity for the reader, definitions of several terms are provided below. It needs to be noted that while some terms are described by using socially or academically accepted definitions, others may be defined solely for the purpose of this study.
Mathematics – According to the Merriam-Webster dictionary mathematics is “the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations” (Merriam-Webster, 2011). A more general definition of this construct, that explains the importance of mathematics in both academic and everyday life, is given by Mac Lane: “Mathematics consists in the discovery of successive stages of the formal structures underlying the world and human activities in that world, with emphasis on those structures of broad applicability and those reflecting deeper aspects of the world” (1981, p. 471).

Mathematics Achievement – Measure of a participant’s mathematics performance. In this study mathematics achievement will be measured by a participant’s score on the mathematics portion of the ACT (for the purpose of our study, it will be denoted by ‘ACT’) and current mathematics course the participants are enrolled in.

Mathematics Performance – A participant’s past and present performance on various assessments in mathematics courses.
Time Without Mathematics - Time period, measured in years, that has passed since the successful completion of the last mathematics course. For the purpose of our study, time without mathematics will be denoted by ‘TWM’.

Perceived Parent Attitude toward Mathematics- The participant’s perception of his/her parents’ attitude toward mathematics. For the purpose of our study, perceived parent attitude toward mathematics will be denoted by ‘PPATM’. More specifically, perceived mother attitude toward mathematics will be labeled ‘PMATM’ and perceived father attitude toward mathematics will be labeled ‘PFATM’.

Perceived Teacher Attitude toward Mathematics - The participant’s perception of his/her teacher’s attitude toward mathematics. For the purpose of our study, perceived teacher attitude toward mathematics will be denoted by ‘PTATM’.

Math Avoidance - Escaping and/or avoiding situations that involve encountering mathematics.

Mathematical Background - Participants’ prior history regarding a number of mathematics courses they have taken and their level of difficulty.
MARS- The Mathematics Anxiety Rating Scale, developed by Richardson and Suinn in 1972, is a commonly accepted measure of math anxiety. A vast amount of psychometric evidence of this instrument supports validity and reliability of MARS scores, however this questionnaire is no longer available.

MARS-Brief – The Mathematics Anxiety Rating Scale – Brief (MARS-Brief) is a modified, 30-item version of the MARS that has been fully validated against the original instrument.

Demographical Questionnaire – A self-report survey comprised of questions related to participants’ demographical characteristics as well as their perceptions of their parent and teacher attitudes toward mathematics.

ACT – The American College Test is a standardized evaluation instrument that “assesses high school students' general educational development and their ability to complete college-level work” (ACT, 2011).

Dimensions – Aspects or characteristics of a phenomenon.

Non-Traditional Student – A student who is 25 years old or older, or one who returns to school after one or more years of employment, homemaking, or other activity.
Summary

One of the biggest obstacles in the path of learning mathematics is math anxiety. This condition, frequently used by many students, teachers, and administrators to explain feelings of tension and fear when faced with mathematics, has been investigated for decades. Seen as a cause of poor math performance and avoidance behavior, it is necessary to attempt and understand the nature of this phenomenon, and to identify possible relationships between math anxiety and its numerous predictors.

We will look at the gender differences in math anxiety levels while taking into the account participants’ age, math achievement, time passed since they had taken their last mathematics course, and their perceived parent and teacher attitude toward mathematics.

In the following chapter we examine the literature related to nature, prevalence, and dimensionality of math anxiety. In addition, an overview of research regarding intricate relationships between math anxiety and multiple factors that is presented in the next chapter, further strengthens the need to investigate and answer the posed research questions.
The theoretical framework for this study is sociocultural theory. This theory is based on the following position proposed by Vygotsky (1978):

Learning awakens a variety of internal development processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers... Learning is not development; however, properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning. Thus learning is a necessary and universal aspect of the process of developing culturally organized, specifically human, psychological functions (p. 90).
In order to understand the learner, it is necessary to consider his or her past experiences and processes that she or he went through, both internally and externally. Learning and development that occurs as a consequence of those experiences take place in social and historical contexts (John-Steiner & Mahn, 1996). As the historical and social contexts constantly change, they provide new opportunities for learning.

Sociocultural theory emphasizes that learning is a process that starts in the social world and reaches the learner, not the other way around (Bonk & Kim, 1998). The process of learning takes place both inside and outside of classroom where two forms of the concepts are developed: the learner’s personal concepts (everyday concepts) that are acquired in everyday life as a result of interactions with other individuals, and academic concepts that are learned in school (Haenen, Schrijnemakers, & Stufkens, 2003). These two types of concepts collide together as the learner goes through the process of mental development.

The main idea that needs to be accentuated as one investigates learning or any processes that may interfere with learning is clearly presented by Vygotsky, “It is
through others that we develop into ourselves” (1981, p. 161). This relationship between social and individual processes in learning and development proposed by Vygotsky is described in three major themes (Wertsch, 1991). The first theme is that individual development originates in the social context the learner experiences. This is followed by the belief that human action is mediated by tools and signs. These semiotics allow for facilitation of knowledge and its internalization in order to ensure future independent problem solving (Scott & Palincsar, n.d.). Finally, the last theme depicted by Wertsch (1991) is that the first two themes are best analyzed through developmental analysis.

The process of learning, as described by Vygotsky, is threatened if feelings of tension and anxiety occur when one is faced with mathematics. Additionally, math anxiety represents obstacles to child’s interaction with people in his environment, and in order to provide an environment conducive to learning, the effects of this condition need to be diminished. According to the sociocultural theory, a new learning process occurs on the basis of past experiences; therefore, several factors causing math
anxiety may also be detrimental for a successful completion of this development. Among more significant factors are parent perceptions of child’s math ability, and their attitudes toward mathematics. Equally important are prior experiences involving mathematics teachers, their beliefs and behaviors regarding mathematics. With this in mind, we begin our discussion of the literature on math anxiety by looking at several definitions of this construct.

Definition of Math Anxiety

The concept of mathematics anxiety has been investigated for decades. The origins of this idea date back to the work of Dreger and Aiken (1957) and their investigation of the concept labeled as number anxiety. Number anxiety is defined as “a syndrome of emotional reactions to arithmetic and mathematics” (Dreger & Aiken, 1957, p. 344).

One of the earliest definitions of mathematics anxiety was provided by Richardson and Suinn (1972). They believed that “Mathematics anxiety involves 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). Based on their definition of math anxiety, Richardson and Suinn developed one of the first instruments used in investigating the concept of mathematics anxiety, the Mathematics Anxiety Rating Scale (MARS). According to their definition, a high score would indicate that a participant is experiencing some anxiety in an academic setting and everyday life.

Math anxiety is also viewed as feelings of “nervousness and associated bodily symptoms related to doing mathematics” (Fennema & Sherman, 1976, p. 326). Tobias and Weissbrod (1980) defined math anxiety as feelings of panic and an extreme sense of helplessness when faced with the task of solving a mathematical problem. Math anxiety has been called an “illness” that causes an emotional dismay when faced with mathematics. (Hodges, 1983; Tobias, 1978).

To explain the overwhelming effect this has on suffering individuals, Tobias described math anxiety as a feeling of “sudden death” (Tobias, 1978). Math anxiety is also seen as a negative attitude toward mathematics that affects math performance (Chavez and Widmer, 1982).
Prevalence of Math Anxiety

Because of the complexity of this phenomenon, the variability in the definitions used to describe it, and the wide range of symptoms reported by those who experience difficulty while doing mathematics, there is no unique measure that reflects the consensus of current thought on this construct that could be used to determine a single, generally agreed-upon estimate of the fraction of the population that is experiencing math anxiety.

Khattoon and Mahmood (2010) report that nearly one-half population (44.98%) of secondary school students who participated in their study, experience moderate levels of math anxiety, while 17.91% of their sample demonstrated high math anxiety. Even more alarming are findings of Perry (2004) who states that approximately 85% of surveyed college students who enroll in introductory mathematics courses report at least moderate math anxiety. Regardless of the exact number of affected students, it is evident that math anxiety is prevalent on college campuses (Betz, 1978).
Before we look into the relationship between math anxiety and the factors related to this phenomenon, we need to examine how the dimensions underlying this construct have been developed in the literature. Simply stated, investigating dimensionality of math anxiety means identifying factors that compose this construct. Better understanding of multiple facets of this phenomenon would provide us with a clear insight into the nature of math anxiety, its causes, and symptoms. Accomplishing this would be very beneficial in a development of successful treatments of math anxiety.

The review of the literature related to math anxiety and instruments measuring this construct, such as the Math Anxiety Rating Scale (MARS) and its antecedents, indicates that not everyone agrees with Richardson and Suinn’s (1972) early claim that math anxiety is unidimensional. Numerous studies have been conducted in order to identify the distinct dimensions underlying math anxiety, as measured by MARS. The most common method used in the process of identification of math anxiety factors has been factor analysis. Factor analysis is a statistical method used to...
examine how underlying constructs or factors influence responses (DeCoster, 1998). In particular, factor analysis “seeks to discover if the observed variables can be explained largely or entirely in terms of a much smaller number of variables called factors” (Darlington, n.d. p.1). Interestingly, the same observed variables may be explained in terms of various factors as a result of different factor analyses. This is due to the type of steps involved in the process of factor analysis, which allow for different approaches among researchers. For example, the third step in the process of factor analysis is selecting the number of factors for inclusion. The number of these factors may be influenced by certain hypothesis, or methods employed to determine the optimal number of factors (DeCoster, 1998). Two different researchers are very likely to investigate different research hypotheses, or to utilize different methods of determining number of factors. Differences in resulting factors may also be a result of a variety of extraction methods used to extract the initial set of factors or numerous types of rotations used for defining factors (Charles, 1995; DeCoster, 1998). Unfortunately, although most researchers identify two or three dimensions
in the MARS, they rarely provide any rationale regarding
the number of their chosen factors.

Factor analysis of the MARS by one set of researchers
resulted in identification of two factors: Mathematics Test
Anxiety and Numerical Anxiety (Rounds and Hendel, 1980).
The Mathematics Test Anxiety factor deals with questions
related to evaluation of one’s math ability, while the
Numerical Anxiety factor includes questions pertaining to
manipulation of numbers in ordinary situations.
Contradictory to these findings is Kagan’s (1987) claim
that anxiety related to the manipulation of numbers is just
another form of test anxiety, not a distinct construct. The
factor relating to the process of testing one’s
mathematical knowledge is also recognized by Brush (1978),
who identified two (differently labeled) dimensions as a
result of factor analysis, Evaluation Anxiety and Problem-
Solving Anxiety. Similar results were also reported by
Plake and Parker (1982). The results of factor analysis of
the MARS-Brief, a shortened, 30-item version of the MARS,
were consistent with the findings of the researchers who
identified Math Test Anxiety and Numerical Anxiety as two
Resnick et al. (1982) identified three independent dimensions: Evaluation Anxiety, Social Responsibility Anxiety, and Arithmetic Computation Anxiety. Evaluation Anxiety refers to an evaluation of the mathematical work, Social Responsibility Anxiety relates to mathematical processes in social settings, and Arithmetic Computation Anxiety involves various arithmetic operations in ordinary life (Resnick et al., 1982). An earlier study by Morris et al. (1978) also isolated three subscales as a result of performing a factor analysis of the MARS: Math Class Anxiety, Math Studying Anxiety, and Math Test Anxiety. The scores on all three subscales highly correlated with the score on the original scale.

In addition to the factors mentioned above, Ferguson (1986) introduced an additional dimension, Abstraction Anxiety. Abstraction Anxiety is anxiety experienced while manipulating abstract expressions in mathematics (Ferguson, 1986). This area of mathematics is first introduced to students in middle grades, and considering that this time period coincides with the first noticeable difference in
math performance in male and female students, it is possible that this phenomenon may be related to this dimension of math anxiety. If this is so, the effects of Abstraction Anxiety may be more significant than what is currently acknowledged (Ferguson, 1986).

Surprisingly, a review of the literature on the dimensionality of math anxiety as measured by the MARS and MARS based instruments revealed a lack of inquiry on the part of the studies in the literature into a relationship between the identified factors and scores on the corresponding subscales. One may expect that the factor dominating the scores on the instrument would coincide with the subscale that has the highest score. For example, Math Test Anxiety was recognized as the first of three factors extracted as a result of factor analysis performed by Alexander and Martray (1989). That factor had the highest average score per item (2.73) compared to the other two. (Average score per item is a ratio of the average score and number of items on the instrument.)

However, the results of a few other studies that reported the scores on their subscales contradict this assumption. The second factor (labeled Evaluation Anxiety)
identified in a factor analysis of the MARS (Brush, 1978) had a higher average score per item (ranging from 1.93 to 2.72) than the first factor (labeled Problem-Solving Anxiety) with average scores per item ranging between 1.33 and 1.66. Similar results are reported by Morris et al. (1978). Of three factors extracted in that study, the second one, Math Test Anxiety, had the highest average score per item of 2.84 (student enrolled in a math course) and 3.14 (students enrolled in a psychology course).

Evaluation Anxiety was also identified as the first of three factors extracted by factor analysis of the MARS by Resnick et al. (1982). This factor, however, had a lower average score per item than the second factor, Social Responsibility Anxiety. Reports of scores on the subscales identified by other researchers would have aided in determining any significant trends between the factors and the subscale scores; unfortunately, this type of data is scarce in the existing literature. It needs to be noted that the order of extraction of factors corresponds to the ranking of their eigenvalues. For example, if a certain factor is extracted first, then its eigenvalue is the largest one of all.
With so many researchers identifying seemingly different factors, a natural question to be asked is if these factors are truly independent and instrument specific. To see if any specific factors are shared by multiple measures of math anxiety Kazelskis (1998) performed a factor analysis of three math anxiety instruments: the Revised Math Anxiety Rating Scale - RMARS (Plake & Parker, 1982), the Mathematics Anxiety Scale – MAS (Betz, 1978), and the Math Anxiety Questionnaire - MAQ (Wigfield & Meece, 1988). Six distinct, but correlated dimensions were identified: Mathematics Test Anxiety, Numerical Anxiety, Mathematics Course Anxiety, Worry, Positive Affect Toward Mathematics, and Negative Affect Toward Mathematics. None of the dimensions were tapped into by all three measures. Interestingly, the factor of Numerical Anxiety appeared to be unique to the R-MARS (Kazelskis, 1998). This is surprising considering that one dimension that is expected to be tapped into by all math anxiety scales would be the one related to manipulation of numbers.

The fact that Numerical Anxiety was only tapped into by one measure, instigates the question of causes of math
anxiety and its possible treatments. Furthermore, it may also be beneficial to examine relationships between math anxiety and other disciplines that may not necessarily involve manipulation of numbers, but they do require similar problem solving skills similar to the ones present in mathematical tasks. Kazelskis (1998) notes that the only factor that was shared by multiple scales was Negative Affect Toward Mathematics, which was identified by the MAS and MAQ. Therefore, math anxiety is yet again seen as a multidimensional construct related to the process of learning and the evaluation of the learning of mathematics.

Although the studies employing factor analysis of the MARS or its modified versions did not necessarily identify the same dimensions, they all recognized factors related to the evaluation of one’s math ability and manipulation of numbers. In the majority of the studies, the Math Test Anxiety factor had the largest eigenvalue (ranging from 13.02 to 32.63) and accounted for the greatest part of the variance (up to 59.2%) compared to the other factors (Alexander and Cobb, 1989; Alexander and Martray, 1989; Bessant, 2005; Plake and Parker, 1982; Resnick et al., 1982; Rounds and Hendel, 1980; Suinn and Winston, 2003).
While the results of the above mentioned studies support the notion that math anxiety is a multidimensional construct, it is important to emphasize that the MARS does not necessarily encompass the entire range of dimensions comprising this phenomenon. It is not that there are two, three, or more underlying dimensions of math anxiety, but rather the MARS taps into that many. This distinction is not always made in the literature. Math anxiety is defined largely by a math test component, followed by a numerical anxiety component (Alexander and Martray, 1989). However, it needs to be emphasized that “The complexity of mathematics anxiety cannot be limited to factors identified in the MARS” (Bessant, 2005, p. 327). This belief led to a development of multiple instruments designed to identify, not only the known factors underlying math anxiety, but possibly the ones not yet presented in the literature.

**Math Anxiety in Pre-Service Teachers**

The far-reaching effects of math anxiety are evident in common teaching practices in today’s classrooms. It is believed that certain instructional techniques, such as teaching directly following textbook examples, lecturing,
and emphasizing only one way to solve a problem are among main causes of math anxiety (Gresham, 2007). Since math anxiety impacts so many individuals, we must expect it to impact at least some students in nearly every discipline, leaving us to ask what happens if the students affected by this condition are future teachers, or more specifically, individuals who will be teaching mathematics?

Math anxiety has been identified as one of the causes of the lack of pre-service teachers’ confidence to teach mathematics. Pre-services teachers experiencing high levels of math anxiety believe that they will not be able to teach mathematics effectively (Bursal and Paznukas, 2006). This is particularly important because teachers’ confidence in their ability to teach mathematics directly affects their students’ math anxiety levels (Vinson, 2001). How students perceive mathematics is strongly linked to what happens in their mathematics classrooms and their teachers’ attitude about mathematics. Specifically, the literature suggests that teachers’ beliefs about mathematics are directly related to their students’ beliefs (Emenaker, 1996).

Understanding where pre-service teachers’ negative attitudes and beliefs about mathematics come from is
essential in an attempt to prevent or at least lessen their impact. Many pre-service teachers report that their beliefs and attitudes stem from their experiences as math students; experiences that frequently involved ill-suited teaching practices (Raymond, 1997). The significance of adequate and effective mathematics teachers in minimizing math anxiety among students is demonstrated in Uusimaki and Nasoni’s (2004) research. Their study, which investigated the causes underlying pre-service teachers’ negative beliefs and anxiety about mathematics, suggests that negative experiences originate in primary schools due to teachers, rather than mathematical content or social factors (Uusimaki and Nason, 2004).

Math anxiety in students has often been created by the classroom teachers in elementary schools (Harper and Daane, 1998). Furthermore, many students associate their first signs of math anxiety with their mathematics teachers, regardless of the level (grade) they were in when it occurred (Chavez and Widmer, 1982; Jackson and Leffingwell, 1992). Student explanation of the causes of their math anxiety included hostile instructor behavior, perception of instructors as insensitive and uncaring, and poor quality
of instruction (Jackson and Leffingwell, 1992). Surprisingly, a qualitative analysis of written responses from pre-service teachers revealed that difficulty of material was identified as a cause of math anxiety only among students at the elementary level. These findings, or more specifically, a lack of these findings in higher grades, may contradict a belief that math anxiety and mathematics achievement are inversely related (Betz, 1978; Engelhard, 2001). Of course, the assumption in this case is that a difficulty level of material negatively affects student performance in mathematics. Unfortunately, Jackson and Leffingwell (1992) did not examine the relationship between content difficulty and mathematical performance.

Due to a significant evidence of detrimental effects of math anxiety on the mathematical performance of various types of students, especially pre-service teachers, it is crucial to focus our efforts on identifying successful and feasible treatments of this condition. Reduction of math anxiety may be effectively accomplished through participation in a mathematics methods course (Gresham, 2007). Successful completion of a course focusing on methods for teaching elementary mathematics significantly
reduces math anxiety levels among pre-service teachers (Harper and Daane, 1998; Vinson, 2001). The themes that emerged from the research indicate that the use of manipulatives throughout the course, combined with an inviting environment created by the instructors, are crucial in the reduction of pre-service teachers’ math anxiety levels (Gresham, 2007; Vinson, 2001). For some students however, math anxiety levels increase after completing the methods course (Vinson, 2001). The reason for this unexpected outcome was that those students have never seen or worked with manipulatives before taking the methods course. Furthermore, the majority of students participating in Gresham’s study commented that “their mathematics anxiety could have been prevented in elementary school if they had received instruction of mathematical concepts through the use of concrete manipulatives” (2007, p. 186). This indicates that this teaching technique needs to be introduced early to all students learning mathematics. However, Gresham (2007) does not indicate which manipulatives were used in the course, or which manipulatives proved to be most effective.
Word problems and problem solving have been reported to be among the dominant causes of math anxiety among pre-service teachers (Harper and Daane, 1998). As a result, mathematics methods courses, which are designed to teach about teaching mathematics, need to include a greater emphasis on these types of problems. Methods courses must include innovative and creative approaches to relating word problems to real life. In words of Harper and Daane, “Methods courses should emphasize working together, using manipulatives, writing about mathematics, and having extensive fieldwork experiences. In addition, the course needs to help students reflect on their own past math experiences and anxiety levels to enable them to create less anxious and more positive mathematics classroom in the future” (1998, p. 38).

Unfortunately, the effects of math anxiety are not bound by mathematics teaching. Research shows that math anxiety also affects elementary science teaching, hence pre-service teachers with low math anxiety report being more confident to teach not only mathematics, but also elementary science (Bursar and Pazuka, 2006). This leads us to believe that research in science teaching or self-
efficacy of science teachers may need to consider other factors that may not be directly linked to this construct. One of these factors affecting science teaching is likely to be math anxiety (Bursar and Pazuka, 2006).

Realizing that students differ in learning styles is another important step in reducing math anxiety. Raising awareness about various learning styles among pre-service teachers and introducing different instructional techniques appropriate for these styles needs to be incorporated in mathematics methods courses. Sloan, Daane, and Giesen’s (2002) findings indicated that math anxiety and global learning style were directly related; hence, global learners experienced higher levels of math anxiety than students with different learning styles. Because global learners are defined as ones who look for a big picture and approach problems in an intuitive manner while focusing on fluency rather than accuracy (Oxford, 1990), it is important that instructional techniques presented in mathematics methods courses are appropriate for this type of learner. For example, global learners prefer open-ended tasks, so they struggle with a traditional, ‘one right answer’ approach (Sloan et al., 2002). Therefore, teaching
methods of mathematics that appears more divergent and less conventional would produce more successful learning outcomes among these students. Needless to say, the effects of learning styles on math anxiety are intertwined with other factors, such as instructional methods, mathematics achievement, etc. This is yet another indicator that predictors of math anxiety are multifaceted and need to be investigated as such.

After a detailed review of the research on math anxiety, Iossi identified three main approaches for reducing math anxiety: curricular strategies (retesting, distance learning, self-paced learning, etc.), instructional (use of manipulatives, technology, and improving communication between instructors and students), and non-instructional strategies (relaxation therapy and psychological treatments) (2007). Additional treatments for reducing the effects of this condition may involve creation of special courses designated only for students exhibiting high levels of math anxiety. Research suggests significant correlation between math anxiety levels and instructional methods. Clute (1984) demonstrates that the students experiencing high math anxiety benefited more from the
expository approach, where lectures were used to present an organized body of knowledge to students; while students with low math anxiety levels performed better under the discovery treatment that was based on questioning sequences that led students to discovering mathematical principles.

Hembree (1990) revealed that certain curricular changes designed to minimize math anxiety were not effective. Some of these changes included presenting material in alternative ways, using tutorials, small-group work, and self-paced assignments. On the other hand, psychological treatments, conducted outside classrooms, that included systematic desensitization and anxiety management training proved to be highly effective treatments for math anxiety.

Gender and Math Anxiety

The relationship between gender and levels of math anxiety has been investigated for decades, and to this date no consensus has been reached. For example, Haynes, Mullins, & Stein (2004) report no significant differences in math anxiety levels in male and female college students, however they identify different factors affecting male and
female levels of math anxiety. More specifically, math anxiety levels for males were significantly related to their general test anxiety and ACT math scores. On the other hand, females’ math anxiety was most strongly affected by their perceived math ability, perceptions of college math teachers’ teaching ability, as well as general test anxiety and ACT math scores (Haynes et al., 2004). Dew, Galassi, and Galassi (1983) claim that while differences in math anxiety between genders may exist, these differences are very small and insignificant.

Some studies report that female college students experience significantly more math anxiety than their male counterparts (Betz, 1978; Khatoon and Mahmood, 2010; Malinsky, Ross, Pannells, & McJunkin, 2006). However, the inconsistencies regarding the effects of gender on math anxiety are present even in these findings. More specifically, while Betz (1978) demonstrated that females reported higher level of math anxiety than males in two of three samples participating in the study, the results in the third cohort were in the opposite direction. The third group, where females reported slightly lower math anxiety levels than males, consisted of students enrolled in more
advanced, college mathematics course. This implies that student math preparedness level is one of the facets affecting the relationship between gender and math anxiety. This is further supported by Brush (1978) who reports higher math anxiety levels for women than men when the mathematics background of participants was not controlled. However, for a sample of men and women with similar mathematics backgrounds, there was no significant difference in the math anxiety experienced by these subjects. In addition, the results of Betz’ study, combined with findings of Dew et al. (1983), lead to a belief that gender differences in math anxiety are related to other factors affecting these experiences.

Unfortunately, there seems to be a lack of consensus when it comes to the relationship between math anxiety and the numerous factors affecting it. Contrary to the findings of Brush (1978), Resnick et al. (1982) report no significant difference in math anxiety levels of males and females within different levels of mathematics courses (starting from Precalculus to more advanced courses). This may be explained by the fact that students, both male and female, at this level of mathematics have all had a
significant amount of math courses in high school; therefore these results could be seen as being consistent if one assumes that by being in this class, the mathematics background of participants was actually controlled.

Richardson and Suinn (1972) indicate that women report more math anxiety than men. Their findings are in agreement with research of Llabre and Suarez (1985) and Woodward (2004) that suggest that math anxiety is more specific in women than it is in men. Hembree (1990) findings support the belief that female students, regardless of grade, report higher math anxiety levels than male students. However, outcomes are not accompanied by expected more negative attitudes toward mathematics, poorer performance, nor avoidance behavior of female students. This contradiction may be explained by Hembree’s assumption that “females may be more willing than males to admit their anxiety, in which case their higher levels are no more than a reflection of societal mores;” and “females may cope with anxiety better.” (1990, p. 45).

That gender affects math anxiety in combination with other factors is also evident in Wigfield and Meece’s (1988) study. While there was no significant difference in
math anxiety in male and female elementary and secondary school students, female students did acknowledge more negative reactions toward mathematics. These negative reactions may be one of the causes of differences in math avoidance behavior of males and females, as well as math anxiety in later years, especially in college. Similar to these results is the report by Malinsky et al. (2006) that states that no significant differences in math anxiety levels of males and females were noted in early grades, but females experienced more math anxiety in college. These research outcomes imply that future research may investigate possible causes of math anxiety in the transition period between early grades and college.

Differences in math anxiety levels as a function of gender are also affected by other aspects of life, such as social desirability. While overall scores on math anxiety measures did not differ significantly for females and males, math anxiety levels for males seems to be highly correlated with measures of social desirability (Zettle & Houghton, 1998). Furthermore, gender was also found to moderate the relationship between math anxiety and math performance (Miller & Bichsel, 2004). Math anxiety levels
are predictive of female performance in basic and applied mathematics tasks, while they were only a statistically significant predictor in basic mathematics tasks for males (Miller & Bichsel, 2004). This further strengthens our proposition that gender needs to be seen as a function of multiple factors, and not as a uni-faceted predictor of math anxiety.

Time Without Mathematics and Math Anxiety

Research shows that there may be a correlation between math anxiety levels and time period that passed without completing a math course. This is also true for a relationship between a number of math courses completed in high school and math anxiety. Taking fewer math courses in high school may correspond to a longer period between a high school math course and math course taken in college. A strong relationship between math anxiety and number of years of high school math was reported (Betz, 1978; Royse & Rompf, 1992). More specifically, students who took fewer math courses in high school exhibited higher levels of math anxiety and were less likely to take more math courses (Hembree, 1990). Betz (1978) considered three groups of
students enrolled in courses involving different levels of mathematics. The first cohort of students was enrolled in the most basic mathematics course offered at the University and it presented a review of high school mathematics. These students had less than three years of mathematics in high school or their placement scores indicated low level of preparedness for general education mathematics course. The second group consisted of students enrolled in a more advanced mathematics course, Precalculus, designated for students planning to major in STEM (science, technology, engineering, medicine) disciplines. Finally, the third group of students was enrolled in an introductory, general education psychology course, and it consisted of students enrolled in a variety of mathematics courses. It was demonstrated that math anxiety levels and years of high school mathematics were correlated regardless of what mathematics course students were enrolled in the college (Betz, 1978). Examining and comparing levels of math anxiety of males and females for all three groups did not reveal any significant differences. This implies that years of high school mathematics, as a predictor of math anxiety, may not be related to gender.
Higher number of years of high school math is inversely related to time period without mathematics for college students. Due to a significant influence of time period without enrolling in a math course on students’ math avoidance behavior, math performance, and math anxiety in college, it is evident that high school math preparation needs to be emphasized and if necessary, improved. More math courses taken in high school would imply that less time would pass between the last high school and first college math course, which in turn may have a positive effect on student math performance and math anxiety in college.

Age and Math Anxiety

One of the possible predictors of math anxiety that is presumably intertwined with both gender and time period without mathematics is age. Because of its strong ties to time without mathematics, the effects of age have often been explored in combination with gender. For example, older women report more math anxiety than their younger counterparts, regardless of their mathematical background (Betz, 1978). This can be explained with the fact that for
non-traditional students, more time has passed since their last math course; therefore, it may not be surprising for them to feel more anxious about mathematics than traditional students. Unfortunately, Betz (1978) fails to provide any comparison of math anxiety levels of traditional and non-traditional male students. Contrary to Betz, Woodard (2004) finds no significant difference in math anxiety based on the age of participants, regardless of their gender. Opposing findings may be due to a notable difference in sample sizes (125 in Woodward’s and 652 in Betz’ study). Regardless of causes of this inconsistency, a lack of consensus regarding the effects of age on math anxiety indicates that additional research may be needed.

Royse and Rompf (1992) looked at the relationship between age and math anxiety, while excluding the effects of gender. Their results indicated that non-traditional students exhibit higher levels of math anxiety than traditional students. Royse and Rompf (1992) believe that this is caused by the fact that many non-traditional students may not have been required to complete as many math courses in high school as are recent high school graduates. That there is a need to further investigate the
relationship between math anxiety and age is also evident in the findings of Malinsky et al. (2006). Their research demonstrates that while there is a correlation between math anxiety and age, a lack of a significant linear trend makes it impossible to determine if older students exhibit more math anxiety.

Perceived Parent Attitude Toward Mathematics and Math Anxiety

It is evident that there is a significant amount of literature regarding the effects of teachers’ beliefs and attitudes toward mathematics and math anxiety levels of their students. However, there is a lack of sufficient and adequate research investigating a relationship between students’ math anxiety levels and their perceived parent attitude toward mathematics. Parental involvement has a significant impact on gender differences in mathematics achievement (Muller, 1998; Trujillo & Hadfield, 1999). It is important to note that Muller used students’ reports regarding their parental involvement; therefore she measured the perceived parental attitude and support which is “more valid for the examination of students’ academic
behavior” (1998, p. 339). This impact is said to be greater than children’s past math performance (Jacobs and Eccles, 1992).

The way parents feel about mathematics is reflected in the attitudes they express in front of their children. One may say that math-anxious parents are more likely to have math anxious children. Indeed, students who experience higher levels of math anxiety report more negative attitude toward mathematics from their parents (Godbey, 1997). Parents’ attitudes about mathematics are strongly linked to beliefs of students about their math ability, which, in turn, are related to their decision to continue their mathematics education. It is suspected that different parental expectations for males and females, parents’ own fears about mathematics, and their positive or negative attitudes toward this subject affect how their children perceive mathematics and their ability (Lazarus, 1974).

Furthermore, research shows that student beliefs are strongly connected to the beliefs of their mothers concerning the difficulty of mathematics for their children. In addition, student beliefs are also related beliefs of their parents about the importance of
mathematics courses for the children (Eccles & Jacobs, 1986). It has been revealed that in general, mothers underestimate their daughters' math ability, while overestimating their sons' math ability (Hyde, Fennema, Ryan, Frost, and Hopp, 1990). This may be significant in the investigation of gender differences in math anxiety, especially considering research findings that imply that females exhibit higher levels of math anxiety than their males. Contrary to these finding, Stuart (2000) fails to demonstrate any relationship between parents' attitudes, beliefs, or perceptions toward mathematics and levels of math anxiety experienced by their children. These inconsistencies further emphasize the existing need for additional examination of effects of parent influence, as perceived by their children, and math anxiety.

It has also been shown that perceptions of parents influence how their children interpret the importance of their math grades (Frome & Eccles, 1998). These results support the notion that math anxiety is directly and strongly influenced by social factors. This is especially true when it comes to beliefs of mothers about the difficulty of the mathematical content (Eccles & Jacobs,
Therefore, the phenomenon of math anxiety seems to involve a significant social component that may explain gender differences in math performance and math-oriented career choices (Eccles & Jacobs, 1986).

Mathematics Achievement and Math Anxiety

Research indicates that the relationship between math anxiety and math achievement is an inverse relationship (Clute, 1974; Betz, 1978; Engelhard, 2001). However, the measures of mathematics achievement and sample of students participating in various research studies are different, and this difference may affect the corresponding findings. For example, Engelhard (2001) used a 40-item mathematics test covering content areas of algebra, arithmetic, and geometry to assess mathematics achievement of students in eighth grade. His findings indicate that higher levels of math anxiety correspond to lower mathematics achievement. The effects of math anxiety on mathematics achievement are significant even after controlling for level of preparedness, mother’s education, and gender (Engelhard,
While this implies that mathematics achievement is an important predictor of math anxiety, the consideration needs to be given to a more standardized measure of this factor in order to generalize the findings to a target population.

Betz (1978) focused on a more standard measure, the math ACT score. Betz (1978) found that higher achievement in mathematics, as measured by math ACT scores, is related to lower levels of math anxiety for both males and females. However, the strength of the correlations between math anxiety and ACT scores varied depending on the level of mathematics preparedness of students. For example, for students with the least level of preparedness who were enrolled in a basic mathematics course, correlations between math anxiety and ACT math scores were marginally significant. On the other hand, in the group consisting of students enrolled in a more advanced mathematics course that requires higher level of mathematics preparedness, the correlations were statistically significant (Betz, 1978). These findings are in agreement with a notion that ACT math scores are directly related to years of high school mathematics.
Contrary to Betz’ findings, the results of Haynes et al. (2004) revealed that while math anxiety levels of male students decreased with an increase in their math ACT scores, math anxiety levels of female students increased. What needs to be noted is that in this study, math ACT scores were only significantly related to females’ math anxiety levels when the factor of perceived math ability was controlled. This indicates that female students who underestimated their math ability tended to have more math anxiety. These findings tie into the previously described relationship between parent and teacher support, which is a reflection of their perceptions about mathematics and mathematical ability of their children and students, and the math anxiety levels they exhibit. These results further support the need to look at gender differences in math anxiety levels while taking into the account the affects of parent or teacher support.

Summary

The concept of mathematics anxiety has been investigated since the early 1970s. One of the earliest definitions of this construct was provided by Richardson
and Suinn (1972). This definition was used to develop one of the most commonly used measures of math anxiety, the Math Anxiety Rating Scale. Math anxiety is viewed as a multidimensional construct related to factors affecting performance, avoidance behavior, and achievement. Considering the powerful effects of this malady on students’ performance, it is important to focus our efforts on developing adequate treatments for minimizing the effects of math anxiety.

Due to inconsistency in the prior research, it is important to further investigate the relationship between gender and math anxiety as a function of several factors. These factors include math achievement, attitude toward mathematics, time period that has passed since the last math course, math preparedness level, and age. Also important are attitudes and beliefs of parents and mathematics teachers as perceived by students.

The following chapter offers an overview of methodology used in the study. In addition, it provides the purpose of the study, poses research questions, and states hypotheses that are examined in this research.
CHAPTER III

METHODOLOGY

This chapter reviews the methodology used in the current study. In addition to the research questions and hypotheses, it also provides an overview of the sample, variables used, and the research design.

Purpose of the Study

The purpose of this study is to investigate whether age, perceived parent and teacher attitudes toward mathematics, level of mathematics preparedness as measured by math ACT scores and current mathematics course, and the length of time passed since completing a math class impact the effects of gender on math anxiety, and if so, how different (if at all) are these impacts for males and females. Dimensions underlying math anxiety as measured by the instrument used in the current study will also be investigated. The relationship between the proposed
predictors and math anxiety will be compared to the relationships between the same independent variables and major dimensions of math anxiety. Based on the extensive overview of the literature presented in the previous chapter, it is expected that the most dominant dimensions based on the instrument are Numerical Anxiety and Math Test Anxiety.

For the purpose of this study, we will use Richardson and Suinn’s definition of math anxiety. Richardson and Suinn define math 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” (1972, p. 551). The main reason for adopting this definition is that this study employs a math anxiety measure developed by Richardson and Suinn, which is based on their definition of this construct.

Research questions

Based on the overview of the literature, we pose the following research questions:
1. Are there gender differences between the correlations of math anxiety with age, level of mathematics preparedness (as measured by ACT scores and current mathematics course), time without mathematics, and perceived teacher and parent attitudes toward mathematics?

2. Are there gender differences between the correlations of numerical anxiety with age, level of mathematics preparedness (as measured by ACT scores and current mathematics course), time without mathematics, and perceived teacher and parent attitudes toward mathematics?

3. Are there gender differences between the correlations of math test anxiety with age, level of mathematics preparedness (as measured by ACT scores and current mathematics course), time without mathematics, and perceived teacher and parent attitudes toward mathematics?

Mathematical representations of the research questions are given by Equations 3.1, 3.2, and 3.3. Descriptions of the variables used in the equations are given in Table 3.1.
\[
MA(G) = a_1(G) + a_2(G) \cdot ACT + a_3(G) \cdot TWM + a_4(G) \cdot AGE +
\]
\[
+ a_5(G) \cdot MC + a_6(G) \cdot PPATM + a_7 \cdot PTATM(G)
\] (3.1)

\[
NA(G) = b_1(G) + b_2(G) \cdot ACT + b_3(G) \cdot TWM + b_4(G) \cdot AGE +
\]
\[
+ b_5(G) \cdot MC + b_6(G) \cdot PPATM + b_7 \cdot PTATM(G)
\] (3.2)

\[
TA(G) = c_1(G) + c_2(G) \cdot ACT + c_3(G) \cdot TWM + c_4(G) \cdot AGE +
\]
\[
+ c_5(G) \cdot MC + c_6(G) \cdot PPATM + c_7 \cdot PTATM(G)
\] (3.3)

Table 3.1
Dependent and independent variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Anxiety</td>
<td>Math anxiety</td>
<td>MA</td>
</tr>
<tr>
<td>Numerical Anxiety</td>
<td>Numerical anxiety</td>
<td>NA</td>
</tr>
<tr>
<td>Math Test Anxiety</td>
<td>Math test anxiety</td>
<td>TA</td>
</tr>
<tr>
<td>Gender</td>
<td>Gender</td>
<td>SEX</td>
</tr>
<tr>
<td>ACT</td>
<td>Math portion of ACT score</td>
<td>ACT</td>
</tr>
<tr>
<td>Time Without Math</td>
<td>Time in years since last time a math course was completed</td>
<td>TWM</td>
</tr>
<tr>
<td>Age</td>
<td>Age</td>
<td>AGE</td>
</tr>
<tr>
<td>Perceived parent attitude</td>
<td>Perceived parent attitude toward mathematics</td>
<td>PPATM</td>
</tr>
</tbody>
</table>
Therefore, the dependent variables in this study are math anxiety, numerical anxiety, and math test anxiety with respect to gender. The independent variables are ACT, time without math, age, math course, perceive parent, and perceived teacher attitude toward mathematics.
Research and Null Hypotheses

Based on the research questions, we pose the following hypotheses:

1. There are gender differences between the correlations of math anxiety with age, ACT scores, mathematics course, time without mathematics, and perceived parent and teacher attitudes toward mathematics.

2. There are gender differences between the correlations of numerical anxiety with age, ACT scores, mathematics course, time without mathematics, and perceived parent and teacher attitudes toward mathematics.

3. There are gender differences between the correlations of math test anxiety with age, ACT scores, mathematics course, time without mathematics, and perceived parent and teacher attitudes toward mathematics.

The null hypotheses generated from the research hypotheses are the following:

1. There are no gender differences between the correlations of math anxiety with age, ACT scores, mathematics course, time without mathematics, and perceived parent and teacher attitudes toward mathematics.
2. There are no gender differences between the correlations of numerical anxiety with age, ACT scores, mathematics course, time without mathematics, and perceived parent and teacher attitudes toward mathematics.

3. There are no gender differences between the correlations of math test anxiety with age, ACT scores, mathematics course, time without mathematics, and perceived parent and teacher attitudes toward mathematics.

These null hypotheses are mathematically represented by Equations 3.4, 3.5, and 3.6.

\begin{align*}
a_i(Male) &= a_i(Female) \quad (3.4) \\
b_i(Male) &= b_i(Female) \quad (3.5) \\
c_i(Male) &= c_i(Female) \quad (3.6) \\
\end{align*}

In conducting this type of a study, it is necessary to consider Type I and Type II errors that may occur as a result of data analysis. Type I error, represented by a variable \( \alpha \), corresponds to rejection of a true null hypothesis. For the purpose of this study, \( \alpha = .05 \). Type II error, on the other hand, results from retaining a false null hypothesis. In general, researchers would rather make a Type II error; that is, one would rather claim that no
difference exists even when it does, than to claim that a difference exists when it does not, which would be a Type I error (Charles, 1995). The probability of these errors is reduced by an increase in the sample size (Utts & Heckard, 2006); therefore, we attempted to diminish this error by choosing an adequate size sample which will be discussed later in this chapter.

**Research Design**

This study was based on the principles of the well established area of survey research design. The data was collected by using directly-administered questionnaires. A directly-administered questionnaire is one that is administered to a group of people gathered at a certain location for a specific reason; for example, in a classroom or as part of an orientation program (Ary, Jacobs, & Razavieh, 1996). The main advantage of this type of data collection is a high response rate, which is frequently 100 percent. The disadvantages include limitations in terms of the location and time of the questionnaire administration. For this study, these limitations were far out-weighted by the ability to ensure a high response rate.
A previously validated instrument measuring math anxiety, the Mathematics Anxiety Rating Scale Brief (MARS-Brief) (Appendix A) and a demographic questionnaire (Appendix B) were administered to the participants during the first week of the academic year. These surveys took place during the last 25 minutes of the participants’ first mathematics class during Fall semester. The approximate completion time for the MARS-Brief was 15 minutes, while completing the demographic questionnaire took approximately 6 minutes. Prior to completing the surveys, the researcher informed the students about the nature of the study, and collected the participants’ consent forms (Appendix C). The purpose of the consent form was to describe the study and obtain permission for the researcher to acquire and use participants’ age and gender information, as well as their ACT achievement scores in mathematics. This information was, with the subjects’ permission, obtained from the research department at the institution that the participants attended. All procedures comprised in the study received the approval of the University’s Human Research Committee (Appendix D).
Sample

The population of interest to this study was all undergraduate students enrolled in first and second year mathematics courses at open enrollment institutions. Our sample of participants was drawn from students enrolled in the first and second year mathematics courses, and the study took place in an open-enrollment, public university located in Northeast Ohio, in a community of approximately 200,000 people. The courses from which the sample was drawn were Intermediate Algebra, College Algebra, Excursions in Mathematics, Precalculus, Calculus with Business Applications, Analytic Geometry Calculus I, and Analytic Geometry Calculus II. Course descriptions are included in Appendix E.

In order to choose a representative sample, a stratified, clustered sampling process was employed. Two sections of Intermediate Algebra, Precalculus, Calculus with Business Applications, Analytic Geometry Calculus I, and Analytic Geometry Calculus II, and one section of College Algebra and Excursions in Mathematics were randomly selected. An approximate enrollment in these courses was around 40 students, except for College Algebra and
Excursions in Mathematics, which had considerably higher enrollment, between 70 to 140 students.

When deciding on the sample size, it is important to remember that the accuracy of conclusion based on data is determined by the size of the sample, not what percentage of the population that sample represents (Ary et al., 1996). The minimum sample size required for a 5% margin of error (confidence interval of 5) with the confidence level of 95% is approximately 384 participants.

**Instrument Measuring Math Anxiety**

Participants in the study completed the Mathematics Anxiety Rating Scale Brief, MARS-Brief (Appendix A) during the first week of the academic year. The MARS-Brief is a shorter version of the Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn in 1972. Like its predecessor, the MARS-Brief was designated to measure feelings of tension related to the manipulation of numbers and the use of mathematical concepts in everyday situations as well as academic settings (Richardson and Suinn, 1972).

For decades, the MARS had been one of the most frequently used instruments in the research of math
anxiety, mostly due to an extensive collection of psychometric data of this measure available in the literature. The original version of MARS was an eight-page instrument containing 98 items. Some research studies report using a 94-item MARS (Rounds & Hendel, 1980). This inconsistency was caused by a printing error of the publisher, the Rocky Mountain Behavioral Science Institute, when the last four items were accidentally omitted (Rounds & Hendel, 1980).

Due to a length of this questionnaire and time constraints it imposed on the researchers in the field, this instrument was modified to include 30, instead of the original 98 items. The inclusion criteria for the scale items were based on the results of three factor analytic studies of the MARS: Alexander and Cobb (1987), Alexander and Martray (1989), and Rounds and Hendel (1998) (Suinn & Winston, 2003). Thirty items selected for the MARS-brief were either included in an important factor in at least two of the studies, or they had the highest factor loading. Items on the MARS-Brief are designed using a Likert format, where responses vary from 1, meaning “not at all”, to 5, meaning “very much”. Individual item scores are summed to produce the final score, which can vary from 30 to 150 for
the 98-item version. As expected, higher scores correspond to higher math anxiety levels.

The MARS-Brief has been successfully validated against the 98 item MARS, resulting in the replacement of this significantly longer scale (MARS, n.d.). The Pearson correlation coefficients for the MARS-Brief with the MARS were significant at $r = .92 (p < .001)$ and $r = .94, (p < .001)$. Additionally, a factor analysis of the modified scale resulted in similar factor loadings as previously reported by the studies analyzing the MARS, as well as identification of two similar factors: numerical anxiety and mathematics test anxiety (Suinn & Winston, 2003).

To further support the validity of the MARS Brief scores, it is also beneficial to examine the psychometric data associated with the MARS. For example, the test-retest reliability coefficient for MARS was calculated to be .85 for a sample of 30 students retested after 7 weeks (Richardson & Suinn, 1972) and .78 for a sample of 119 student retested after 2 weeks, which are comparable to reliability coefficients reported for other scales used in practice (Suinn, Eddie, Nicoletti, & Spinelli, 1972). Further, the average intercorrelation of the instrument items was determined to be high as demonstrated by the
value of .97 reported for the coefficient alpha. Such a high internal consistency reliability coefficient supports Richardson and Suinn’s claim that math anxiety is a unidimensional construct, as it appears that the test items are heavily dominated by a single homogeneous factor (Richardson & Suinn, 1972).

Validity of the math anxiety scores obtained from the MARS is also supported based on evidence of discriminant validity. As demonstrated by its developers, the MARS scores were negatively correlated with the Numerical Ability subtest of the Differential Aptitude Test results (correlation coefficient $r = -.64$, sample size $n = 30$; $r = -.35$, $n = 44$). Furthermore, the authors also conducted a study whose findings indicated that the MARS scores of the experimental group, which received a math anxiety treatment, significantly decreased compared to the scores of the control group, which received no treatment (Suinn et al., 1972).

Brush (1978) provided additional validity evidence for the MARS. In this work it was reported that math anxiety levels were negatively correlated with the years of high school mathematics ($r = -.44$, $p < .001$). These math anxiety levels were also checked for association with negative
reactions on the part of the participants to studying mathematics. In addition to these validity measures, a high correlation factor between MARS and the Suinn Test Anxiety Behavior Scale (STABS) indicates that math anxiety and test anxiety are related constructs (Brush, 1978). In interpreting these results, however, it is important to note that STABS was also developed by Suinn, and that the similarities between the questions may have affected the correlation factor between the two anxiety measures. Therefore, these results should not be considered a sufficient basis for any conclusions about the inter-relation between math anxiety and test anxiety.

While there is no extensive collection of psychometric data for a modified version of the MARS, Suinn and Winston (2003) complemented the validation of the MARS-Brief against the original questionnaire by providing certain validity and reliability of the MARS-Brief scores. Internal consistency was high, with a Cronbach alpha of .96. The one week, test-retest reliability was reported to be .90 with $p < .001$ (Suinn & Winston, 2003). Furthermore, Suinn and Winston (2003) demonstrated that the MARS-Brief scores were significantly negatively correlated with mathematics performance in high school ($r = -.41$ and $r = -.31$ with $p < .001$).
They also showed that the scores were negatively correlated with mathematics-related major choice ($r = -.36$ and $r = -.33$ with $p < .001$). As previously mentioned, the MARS-Brief has replaced the original, significantly longer scale; however Suinn and Winston (2003) emphasized that in order for this scale to be used diagnostically, normative research would be necessary.

**Demographic Questionnaire**

In addition to completing the MARS-Brief, the participants were also administered a questionnaire including questions of demographical nature and questions regarding their perception of their parents’ and teachers’ attitudes toward mathematics (Appendix B). The demographic questionnaire has a structured response format, and all items are single-option variables. The items regarding the participants’ perception of their parent or teacher attitudes toward mathematics utilize a Likert format, with responses varying from 1, “strongly disagree”, to 5, “strongly agree”. These items are divided into three subscales. These subscales measure perceived mother attitude, perceived father attitude, and perceived teacher
attitude toward mathematics. Each subscale consists of 13 questions; therefore, the minimum possible score is 13, corresponding to a significant lack of positive attitude toward mathematics. The maximum attainable score is 65. Higher scores correspond to a perception of more positive parent or teacher attitude toward mathematics.

In order to ensure that the demographic questionnaire adequately measures students’ perception of their parent and teacher attitudes toward mathematics, the three subscales were piloted prior to administering the survey to our sample. Twelve undergraduate students were asked to answer the survey questions regarding their parent or teacher attitude toward mathematics, and then participate in a short, structured interview. Because the majority of codes produced by coding of interview transcripts emerge in the first twelve interviews (Guest, Bunce, & Johnson, 2006), this number of participants was highly likely to result in reaching the saturation point in the responses.

The students participating in the pilot study were purposefully chosen by the researcher to include (three male and three female) students who were majoring in a STEM discipline, and (three male and three female) students who were majoring in a social science and have already
completed their general education mathematics requirement. The criterion for selecting these participants was based on an assumption that a perceived attitude toward mathematics provided by an authoritative figure (such as a parent or teacher) was directly related to student math performance.

The interviews were designed to determine what kind of attitude toward mathematics the students perceived their teachers or parents to have. The goal of the pilot study was to establish that the themes that emerged from the interviews corresponded to the questionnaire items. The interviews were structured and contained two prompts:

1. Please describe your parent’s attitudes toward mathematics. How did these attitudes reflect in their behavior? Please address their attitudes about your ability to do mathematics. What impact did your parent’s attitude have on your attitude and beliefs toward mathematics? Did it affect your major (career) choice? Add any additional comments if needed.

2. Please describe your teacher’s attitudes toward mathematics. How did these attitudes reflect in their behavior? Please address their attitudes about your ability to do mathematics. What impact did your
teacher’s attitude have on your attitude and beliefs toward mathematics? Did it affect your major (career) choice? Add any additional comments if needed.

All interviews were transcribed and coded. Transcriptions are given in Appendix F. The following 8 codes emerged from the qualitative data collected in the interviews:

1. Parent Attitudes (PA)
   Perceived parent’s attitudes, positive or negative, toward mathematics.

2. Teacher Attitudes (TA)
   Perceived teacher’s attitudes, positive or negative, toward mathematics.

3. Parent Assistance (PAS)
   Perceived parent assistance in mathematics assignments.

4. Teacher Assistance (TAS)
   Perceived teacher assistance in mathematics assignments.

5. Parent Support (PS)
   Perceived parent support in learning mathematics.

6. Teacher Support (TS)
Perceived teacher support in learning mathematics.

7. Parent Ability (PAB)

Perceived parent’s ability in mathematics.

8. Teacher Ability (TAB)

Perceived teacher’s ability in mathematics.

The correspondences between the emerged codes and the questionnaire items are given in Table 3.2.

Table 3.2
Correspondence between the codes and questionnaire items.

<table>
<thead>
<tr>
<th>Code</th>
<th>Questionnaire Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Attitude</td>
<td>6(1ab), 6(3ab), 6(9ab),</td>
</tr>
<tr>
<td></td>
<td>6(11ab), 6(12ab)</td>
</tr>
<tr>
<td>Parent Ability</td>
<td>6(2ab), 6(4ab), 6(10ab)</td>
</tr>
<tr>
<td>Parent Support</td>
<td>6(5ab), 6(7ab), 6(8ab),</td>
</tr>
<tr>
<td></td>
<td>6(13ab)</td>
</tr>
<tr>
<td>Parent Assistance</td>
<td>6(6ab)</td>
</tr>
<tr>
<td>Teacher Attitude</td>
<td>5(1), 5(3), 5(9), 5(11),</td>
</tr>
<tr>
<td></td>
<td>5(12)</td>
</tr>
<tr>
<td>Teacher Ability</td>
<td>5(2), 5(4), 5(10)</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>5(5), 5(7), 5(8), 5(13)</td>
</tr>
<tr>
<td>Teacher Assistance</td>
<td>5(6)</td>
</tr>
</tbody>
</table>
Further supporting the notion that the questionnaire adequately measures student perception of their parent(s) and teacher attitudes toward mathematics are the questionnaire scores of the pilot participants. The participants who revealed in their interviews that their parent’s or teacher’s attitude toward mathematics were overall negative, scored lower on the questionnaire than the participants whose parent(s) or teachers had positive attitude toward mathematics in general.

**Internal and External Validity**

In order to determine the quality, as well as the adequacy of the design of the study, both internal and external validity need to be examined.

Internal validity is defined as “the extent to which extraneous variables have been controlled by the researcher, so that any observed effect can be attributed solely to the treatment variable” (Gall, Gall, and Borg, 2007, p. 383). Due to a lack of control and experimental group, survey research is weak on internal validity, because it is very difficult to determine a causal relationship. We attend to this potential concern by
employing a multivariate data analysis, which is addressed in the next chapter. Another threat to internal validity of this study is the adequacy of the psychometric data of the MARS-Brief. In order to minimize this threat, in addition to accepting the existing validity and reliability evidence provided in the literature, we provide additional psychometric evidence by performing a factor analysis of the MARS Brief scores. The procedure, as well as the results of the factor analysis are provided in the following chapter.

External validity is “the extent to which the findings of an experiment can be applied to individuals and settings beyond those that were studied” (Gall et al., 2007, p. 388). Being able to generalize a study’s findings relies on “the definition of the population of interest, the sampling method used and validity and reliability of measurement” (Peers, 1996, p. 4). If the sample is not designed to be representative, then it is not realistic to generalize beyond the population from which that sample was chosen. Therefore, to minimize any potential concerns over the external validity of our study, we employed random sampling of the sections selected for each course to obtain a sample representative of the total population.
Summary

The goal of this study was to investigate whether there were gender based differences in the relationship between math anxiety and age, perceived parent and teacher attitude toward mathematics, math ACT scores, math course, and the length of time passed since completing a math class. In order to determine the nature of these relationships, this study employed a survey research design. The data was collected by utilizing the MARS-Brief and a demographic questionnaire. These measures were administered to undergraduate students enrolled in first and second year mathematics courses during the first week of a fall semester.

The collected data was analyzed by utilizing factor analysis, examining correlations between dependent and independent variables, and performing multiple regression analyses. These methods, as well as the results of this study are presented in the next chapter.
CHAPTER IV

RESULTS

The purpose of this study was to determine if there were gender differences in the impact of the potential predictors on math anxiety. These predictors included the age of the participants, time passed since they completed a math course, the scores on the math portion of ACT, and perceived parent and teacher attitudes toward mathematics. In addition, the intent was to identify, if any, gender differences in the relationships between the predictors and the major dimensions underlying math anxiety.

In order to address the corresponding research questions, data was collected from the selected representative sample. The data measured the participants’ math anxiety levels, their perceptions of the attitudes toward mathematics expressed by their parents and teachers, and finally the participants’ demographic information. While the previous chapter described the methods for
collecting this data, the current chapter gives a detailed analysis of the collected data and lists the findings.

Demographic Questionnaire

Demographics

Prior to the administration of the MARS-Brief (Appendix A), the participants were asked to complete the demographic questionnaire (Appendix B). This questionnaire asked for information regarding the participants’ gender, age, current status in school, and the last time they completed a math course. It also contained three subscales that were focused on the students’ perceptions of attitudes toward mathematics expressed by their parents and teachers. Each subscale consisted of 13 items utilizing a Likert scale from 1 to 5. Therefore, the scores one each subscale could range from 13 to 65.

Five hundred and forty nine students were enrolled in the first and second year mathematics courses that were randomly selected to participate in the study. The produced sample was modified to include only undergraduate students, and excluded any graduate students, students auditing the course, and post secondary students (high school students enrolled in college-credit granting classes). Also excluded
were students who did not complete the MARS-Brief and/or demographic questionnaire. Finally, excluding students who either did not complete math achievement assessments (ACT or SAT) or did not report their scores resulted in the sample size of 473.

As shown in Figure 4.1, female students comprised 38.27% of the sample (181 students), and male students represented 61.73% (292 students).

![Figure 4.1. Gender distribution of the sample. Sample consisted of more male students, 61.73%, than female students who comprised 38.27% of the sample.](image)

The participants’ age ranged from 17 to 46, with the average age of 20.1 years. The distributions of age for
female and male students are given in Figures 4.2 and 4.3 respectively.

Figure 4.2. Distribution of age for female students.
Figure 4.3. Distribution of age for male students.

The final number of the participants from each course is presented in Table 4.1. The participants were also categorized based on their status in school as freshmen, sophomores, juniors and seniors. Figure 4.4 shows number of the participants according to their status in school. This figure, as well as Table 4.2, indicates that the majority of the sample, 82.45%, consisted of freshman and sophomore students.
Table 4.1

Participants from each course

<table>
<thead>
<tr>
<th>Course</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate Algebra</td>
<td>60</td>
</tr>
<tr>
<td>Excursions in Mathematics</td>
<td>59</td>
</tr>
<tr>
<td>College Algebra</td>
<td>128</td>
</tr>
<tr>
<td>Precalculus</td>
<td>28</td>
</tr>
<tr>
<td>Calculus With Business Applications</td>
<td>66</td>
</tr>
<tr>
<td>Analytical Geometry Calculus I</td>
<td>62</td>
</tr>
<tr>
<td>Analytical Geometry Calculus II</td>
<td>77</td>
</tr>
</tbody>
</table>

Figure 4.4. Status in school. Majority of the sample consisted of freshman and sophomore students, 82.45%.
Table 4.2
Counts and percentages of participants’ status in school

<table>
<thead>
<tr>
<th>Status</th>
<th>Count</th>
<th>Percentage of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>210</td>
<td>44.40</td>
</tr>
<tr>
<td>Sophomore</td>
<td>180</td>
<td>38.05</td>
</tr>
<tr>
<td>Junior</td>
<td>60</td>
<td>12.69</td>
</tr>
<tr>
<td>Senior</td>
<td>18</td>
<td>3.81</td>
</tr>
<tr>
<td>Not reported</td>
<td>5</td>
<td>1.05</td>
</tr>
</tbody>
</table>

Figure 4.5 shows distribution of time passed since the last time the participants completed a mathematics course. It can be seen from Figure 4.5 and Table 4.3, that most students, 64.48%, who participated in the current study completed a mathematics course the previous semester.
Figure 4.5. Frequencies of time without mathematics.

Majority of the sample, 64.48%, completed a mathematics course the previous semester.
Table 4.3
Approximate number of years passed since completing a math course

<table>
<thead>
<tr>
<th>Time when last math course was taken</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last semester</td>
<td>305</td>
<td>64.48</td>
</tr>
<tr>
<td>Approximately 1 year ago</td>
<td>123</td>
<td>26.00</td>
</tr>
<tr>
<td>Approximately 2 years ago</td>
<td>30</td>
<td>6.34</td>
</tr>
<tr>
<td>Approximately 3 years ago</td>
<td>6</td>
<td>1.27</td>
</tr>
<tr>
<td>Approximately 4 years ago</td>
<td>4</td>
<td>0.85</td>
</tr>
<tr>
<td>More than 5, but less than 10 years ago</td>
<td>2</td>
<td>0.42</td>
</tr>
<tr>
<td>10 years ago or longer</td>
<td>3</td>
<td>0.64</td>
</tr>
</tbody>
</table>

There was a very small percentage of the participants who had more than 3 years pass before taking a mathematics course again. More specifically, only 1.91% of students completed a mathematics course approximately 4 or more years ago. The distributions of time without mathematics for female and male students are given in Figures 4.6 and 4.7 respectively.
Figure 4.6. Distribution of time without mathematics for female students.
Figure 4.7. Distribution of time without mathematics for male students.

The relationship between time without mathematics and age was examined for both genders. Pearson coefficient was small, but statistically significant at \( p = 0.01 \) level (\( r = 0.377 \)) for female students, as shown in Figure 4.8. However, age and time without mathematics were not correlated for male students.
Figure 4.8. Relationship between time without mathematics and age for female students. Time without mathematics and age of female students were positively correlated.

Subscales: Perceived mother and father attitudes toward mathematics

Before examining the scores on the subscales pertaining to perceived parent attitudes toward mathematics, it was necessary to look at the distribution of both variables (PMATM and PFATM) for female and male students. For female students, the mean on the perceived mother attitude toward mathematics subscale was 41.04 (SD = 8.20), while the mean on the perceived father attitude
toward mathematics subscale was 42.48 (SD = 11.68). The distributions of these variables are given in Figure 4.9 and 4.10 respectively.

Figure 4.9. Distribution of the scores on the perceived mother attitude toward mathematics subscale for female students.
Figure 4.10. Distribution of the scores on the perceived father attitude toward mathematics subscale for female students.

To better understand how perceived mother and father attitudes toward mathematics for female students were related, the means on the corresponding demographic questionnaire subscales were compared using a dependent t-test. Results from a dependent t-test indicated that this
difference was not statistically significant, \( t(180) = 1.675, p = 0.096 \).

A Pearson product-moment correlation coefficient was computed to assess the relationship between the scores on the perceived mother and perceived father attitude toward mathematics subscales for females. As shown in Figure 4.11, there was a relatively weak, but statistically significant correlation between the two variables, \( r = 0.363, n = 181, p = 0.05 \).

Figure 4.11: Correlation between perceived mother and father attitude toward mathematics for females. PMATM and
PFATM are weakly, but significantly correlated for female students.

The means on the perceived mother and perceived father attitude toward mathematics subscales for male students were 41.77 (SD=6.77) and 44.35 (SD=9.80) respectively. The distributions of these variables are given in Figures 4.12 and 4.13, respectively.

Figure 4.12. Distribution of the scores on the perceived mother attitude toward mathematics subscale for male students.
Comparing the means on the perceived mother and perceived father attitude toward mathematics subscales for male students indicated a significant statistical difference, $t(291) = 4.198, p = 0.0$. A Pearson coefficient was calculated to be $r=0.243, n=292, p=0.05$, which indicated a statistically significant, but weak correlation between the perceived mother and perceived father attitudes toward mathematics.
mathematics for male students. Figure 4.14 gives a visual representation of this relationship.

Figure 4.14: Correlation between perceived mother and father attitude toward mathematics for males. PMATM and PFATM in mathematics are weakly, but significantly correlated for male students.

Weak, although statistically significant, correlations between the scores on the perceived mother and perceived father attitude toward mathematics subscales for both males and females indicated that these variables needed to be considered as distinct effects on math anxiety. More specifically, for both genders, the perceived mother and perceived father attitude toward mathematics variables

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would replace the perceived parent attitude toward mathematics variable in the investigation of effects on math anxiety. Additionally, these two variables were not correlated with age of students. The Pearson correlation coefficients were -0.165 and -0.209 respectively, and they were not statistically significant.

**Perceived Teacher Attitude Toward Mathematics**

The third subscale included in the demographic questionnaire pertained to the attitudes toward mathematics that the participants perceived their mathematics teachers to have. Comparing means of the scores on the perceived teacher attitude toward mathematics scales for male and female students using an independent t-test revealed that males were more likely to perceive their teachers to have positive attitudes toward mathematics \( (52.69, SD = 7.30) \), than their female counterparts \( (50.72, SD = 7.64) \). The difference in the means was statistically significant at \( t(47) = 2.799, p < 0.05 \). The distributions of the scores on the perceived teacher attitude toward mathematics subscales for females and males are given in Figures 4.15 and 4.16, respectively.
Figure 4.15. Distribution of the scores on the perceived teacher attitude toward mathematics subscale for female students.
To identify who was perceived to have the most positive attitude toward mathematics, the means on the perceived mother and perceived father attitude toward mathematics subscales were compared to the means on the perceived teacher attitude toward mathematics subscale for both females and males. The results are shown in Figure 4.17.
To see if the difference between the perceived attitudes toward mathematics expressed by teacher and any of the parents was significant for males and females, the means were compared using dependent t-tests. These tests revealed that perceived teacher attitudes were more positive than either perceived mother or perceived father attitudes toward mathematics for both males and females. The details of the performed dependent t-tests are given in Table 4.4.
Table 4.4
Dependent t-tests for perceived mother, father, and teacher attitudes toward mathematics

<table>
<thead>
<tr>
<th>Gender</th>
<th>Pair</th>
<th>95% Confidence Interval</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>of the Difference</td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>Mother-Teacher</td>
<td>-11.06863</td>
<td>-8.30154</td>
<td>-13.813</td>
<td>180</td>
</tr>
<tr>
<td>Female</td>
<td>Father-Teacher</td>
<td>-10.04179</td>
<td>-6.44440</td>
<td>-9.043</td>
<td>180</td>
</tr>
<tr>
<td>Male</td>
<td>Mother-Teacher</td>
<td>-11.9475</td>
<td>-9.88812</td>
<td>-20.868</td>
<td>291</td>
</tr>
<tr>
<td>Male</td>
<td>Father-Teacher</td>
<td>-9.67183</td>
<td>-7.01995</td>
<td>-12.388</td>
<td>291</td>
</tr>
</tbody>
</table>

98
Factor Analysis of MARS-Brief

In order to gain a better understanding of what the instrument, MARS-Brief, truly measures, we performed a factor analysis of the scores. Prior to extracting the factors from the data, a visual check consisting of scanning the correlation matrix for high correlation coefficients was performed in order to confirm that factor analysis would produce meaningful results. This process revealed strong correlations between variable 4 and variables 3 and 5 (0.846 and 0.867 respectively), as well as variable 30 with variables 28 and 29 (0.803 and 0.865 respectively). Because correlations of 0.85 or higher indicate redundancy of scale items, it is recommended to eliminate one or more of these variables (Norman and Streiner, 2008). With this in mind, variables 4 and 30 (corresponding to items 4 and 30 on the MARS-Brief) were eliminated from the data. Additionally, a high chi-square statistics of 11306.341 resulting from the Barlett test of sphericity indicated that we should proceed with factor analysis. This was further supported by the Kaiser-Meyer-Olkin measure of sampling adequacy, where the MSA value for each variable was above 0.90.
The number of factors to be extracted was determined by employing the eigenvalue one test and the Cattel’s scree test. According to the eigenvalue one test, the only factors that should be extracted are the one with a corresponding eigenvalue of 1 or higher (Norman and Streiner, 2008). Utilizing this test, six factors that had eigenvalues greater than unity were identified. (The eigenvalues for all factors are shown in Table 4.5.)

Table 4.5

Eigenvalues for each factor

<table>
<thead>
<tr>
<th>Factor</th>
<th>Eigenvalue</th>
<th>% of variance</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.220</td>
<td>42.430</td>
<td>42.430</td>
</tr>
<tr>
<td>2</td>
<td>4.277</td>
<td>12.760</td>
<td>55.191</td>
</tr>
<tr>
<td>3</td>
<td>1.812</td>
<td>5.407</td>
<td>60.598</td>
</tr>
<tr>
<td>4</td>
<td>1.383</td>
<td>4.125</td>
<td>64.723</td>
</tr>
<tr>
<td>5</td>
<td>1.140</td>
<td>3.402</td>
<td>68.124</td>
</tr>
<tr>
<td>6</td>
<td>1.048</td>
<td>3.127</td>
<td>71.252</td>
</tr>
<tr>
<td>7</td>
<td>.941</td>
<td>2.807</td>
<td>74.058</td>
</tr>
<tr>
<td>8</td>
<td>.881</td>
<td>2.629</td>
<td>76.688</td>
</tr>
<tr>
<td>9</td>
<td>.782</td>
<td>2.334</td>
<td>79.021</td>
</tr>
<tr>
<td>10</td>
<td>.688</td>
<td>2.052</td>
<td>81.073</td>
</tr>
<tr>
<td></td>
<td>Eigenvalue 1</td>
<td>Eigenvalue 2</td>
<td>Cumulative Sum</td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>-------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>11</td>
<td>.635</td>
<td>1.894</td>
<td>82.967</td>
</tr>
<tr>
<td>12</td>
<td>.574</td>
<td>1.712</td>
<td>84.679</td>
</tr>
<tr>
<td>13</td>
<td>.557</td>
<td>1.663</td>
<td>86.342</td>
</tr>
<tr>
<td>14</td>
<td>.533</td>
<td>1.590</td>
<td>87.933</td>
</tr>
<tr>
<td>15</td>
<td>.492</td>
<td>1.467</td>
<td>89.400</td>
</tr>
<tr>
<td>16</td>
<td>.456</td>
<td>1.362</td>
<td>90.762</td>
</tr>
<tr>
<td>17</td>
<td>.410</td>
<td>1.224</td>
<td>91.986</td>
</tr>
<tr>
<td>18</td>
<td>.375</td>
<td>1.119</td>
<td>93.105</td>
</tr>
<tr>
<td>19</td>
<td>.345</td>
<td>1.031</td>
<td>94.136</td>
</tr>
<tr>
<td>20</td>
<td>.328</td>
<td>.978</td>
<td>95.114</td>
</tr>
<tr>
<td>21</td>
<td>.288</td>
<td>.858</td>
<td>95.972</td>
</tr>
<tr>
<td>22</td>
<td>.280</td>
<td>.835</td>
<td>96.807</td>
</tr>
<tr>
<td>23</td>
<td>.236</td>
<td>.703</td>
<td>97.511</td>
</tr>
<tr>
<td>24</td>
<td>.223</td>
<td>.666</td>
<td>98.177</td>
</tr>
<tr>
<td>25</td>
<td>.196</td>
<td>.584</td>
<td>98.761</td>
</tr>
<tr>
<td>26</td>
<td>.181</td>
<td>.539</td>
<td>99.300</td>
</tr>
<tr>
<td>27</td>
<td>.124</td>
<td>.369</td>
<td>99.669</td>
</tr>
<tr>
<td>28</td>
<td>.111</td>
<td>.331</td>
<td>100.000</td>
</tr>
</tbody>
</table>

However, the Cattel’s scree test suggests plotting the eigenvalues and recognizing the factor before the scree as the last one to be included (Norman and Streiner, 2008). Based on the scree plot, given in Figure 4.18, it was
decided that only 4 factors should be extracted. Principal factor analysis was used to identify items on the instrument that did not load strongly (or at all), on any of the identified factors. Two rotation methods were considered for this study: orthogonal and oblique rotations. An orthogonal rotation is deemed more appropriate if the factors are independent (orthogonal), while an oblique rotation is more suitable for factors that are related to each other (Norman and Streiner, 2008).

Figure 4.18. The scree plot of factors. There are four eigenvalues before the scree, implying that four factors should be extracted in the factor analysis.
The first rotation method used was the orthogonal varimax rotation, which yielded 4 independent factors. Upon further examination, however, the rotated factor loading matrix revealed 4 factorially complex variables (variables that load strongly on two or more factors). By looking at Table 4.6, we identify variables 10, 14, 15, and 7 as factorially complex.

Table 4.6:
Rotated factor loading matrix for the orthogonal varimax solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>.843</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>.800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>.752</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>.749</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>.735</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>.735</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>.733</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>.721</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>.720</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>.717</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>----</td>
<td>----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>.626</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>.578</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>.554</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>.540</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>.859</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.811</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>.765</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>.724</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>.684</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>.661</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>.524</td>
<td>.487</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>.518</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>.505</td>
<td>.489</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>.477</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>.411</td>
<td>.642</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>.631</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>.465</td>
<td>.656</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>.586</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The presence of these factorially complex variables supported the assertion that the set of factors were not completely independent. This suggested that the analysis should employ an oblique promax rotation. Rotated factor
loading matrix (which in the case of an oblique rotation refers to the pattern coefficient matrix) given in Table 4.7 indicated strong variable loadings on four extracted factors. It needs to be noted that “strong” loadings were considered to be the ones with values that were higher than 0.4; therefore, all loadings of 0.4 and below were excluded from the rotated factor loading matrices.

Table 4.7
Rotated factor loading matrix for the oblique promax solution

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>0.901</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>0.846</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>0.806</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0.793</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>0.776</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0.763</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.763</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0.751</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>0.726</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>0.717</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>0.624</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
After comparing factor loadings for two methods of rotation, it was evident that the same variables loaded strongly on Factors 1 and 4. However, the oblique rotation yielded a simple structure regarding Factors 2 and 3, which no longer contained factorially complex variables. Lastly,
while as a result of the orthogonal rotation, variables 8 and 11 loaded on Factor 2 (0.518 and 0.477 respectively), these variables were not strongly loaded (less than 0.4) on any of the factors resulting from the oblique rotation. Because the underlying assumption of the orthogonal rotation approach is that the factors are completely independent, use of this method would require that any items loading on multiple variables be excluded. In the present study, that would mean eliminating 4 factorially complex variables. As mentioned previously, the oblique rotation approach accounts for the possibility that the factors may be somewhat related, and would not require a loss of variables (except the removal of variables 8 and 11 because they did not load strongly on any factor). In order to avoid eliminating factorially complex variables from the data set prior to interpreting the factors and because the promax oblique solution provided a more structurally simple representation of the results, the factors extracted by this rotation were selected for presentation.

As mentioned previously, due to their low loadings on every factor, variables 8 and 11 were excluded from data. These variables correspond to items 8 and 11 of the MARS-Brief:
8. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.

11. Taking the math section of a college entrance exam.

Of the remaining 28 variables, 14 strongly loaded on Factor 1, which accounted for 42.43% of the variance of the MARS-Brief scores (Eigenvalue = 14.22). This factor, labeled Numerical Anxiety, pertains to a manipulation of numbers in ordinary situations. The items measuring Numerical Anxiety are given in Table 4.8.

Table 4.8
MARS-Brief items loading on Factor 1 (Numerical Anxiety)

<table>
<thead>
<tr>
<th>Loading</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.901</td>
<td>29</td>
<td>Being given a set of subtraction problems to solve.</td>
</tr>
<tr>
<td>.846</td>
<td>21</td>
<td>Being given a set of numerical problems involving addition to solve on paper.</td>
</tr>
<tr>
<td>.806</td>
<td>23</td>
<td>Totaling up a dinner bill that you think overcharged you.</td>
</tr>
<tr>
<td>.793</td>
<td>18</td>
<td>Reading a cash register receipt after your purchase.</td>
</tr>
<tr>
<td>.776</td>
<td>27</td>
<td>Watching someone work with a calculator.</td>
</tr>
<tr>
<td>.763</td>
<td>17</td>
<td>Adding up 976+777 on paper.</td>
</tr>
</tbody>
</table>
Six other variables, given in Table 4.9, had strong loadings on Factor 2. Labeled Math Test Anxiety, this factor was related to the assessment of one’s math ability.
in academic settings, and accounted for 12.76% of the total variance (Eigenvalue = 4.28).

Table 4.9

MARS-Brief items loading on Factor 2 (Math Test Anxiety)

<table>
<thead>
<tr>
<th>Loading</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.009</td>
<td>3</td>
<td>Thinking about an upcoming math test one day before.</td>
</tr>
<tr>
<td>.909</td>
<td>1</td>
<td>Taking an examination (final) in a math course.</td>
</tr>
<tr>
<td>.857</td>
<td>5</td>
<td>Thinking about an upcoming math test five minutes before.</td>
</tr>
<tr>
<td>.728</td>
<td>2</td>
<td>Thinking about an upcoming math test one week before.</td>
</tr>
<tr>
<td>.607</td>
<td>9</td>
<td>Being given a “pop” quiz in a math class.</td>
</tr>
<tr>
<td>.536</td>
<td>12</td>
<td>Taking an examination (quiz) in a math course.</td>
</tr>
</tbody>
</table>

The third factor, pertaining to a process of learning mathematics, was associated with four variables, as shown in Table 4.10. This factor, labeled Math Learning Anxiety, accounted for 5.41% of the total variance (Eigenvalue = 1.81).
Table 4.10

MARS-Brief items loading on Factor 3 (Math Learning Anxiety)

<table>
<thead>
<tr>
<th>Loading</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.806</td>
<td>13</td>
<td>Picking up the math text book to begin working on a homework assignment.</td>
</tr>
<tr>
<td>.802</td>
<td>15</td>
<td>Getting ready to study for a math test.</td>
</tr>
<tr>
<td>.584</td>
<td>14</td>
<td>Being given a homework assignment of many difficult problems which is due the next class meeting.</td>
</tr>
<tr>
<td>.546</td>
<td>10</td>
<td>Studying for a math test.</td>
</tr>
</tbody>
</table>

The final factor, labeled Math Grade Anxiety, was related to receiving a grade on a math assessment. It was associated with two variables, and accounted for 4.13% of the total variance (Eigenvalue = 1.38). The MARS-Brief items loading high on this factor are shown in Table 4.11.

Considering the nature of these four factors, one might expect to see a certain level of correlation among them. Correlation coefficients between the factors, shown in Table 4.12, vary from 0.386 (between Numerical Anxiety and Math Test Anxiety) to 0.673 (between Math Test Anxiety and Math Grade Anxiety).
Table 4.11

MARS-Brief items loading on Factor 4 (Math Grade Anxiety)

<table>
<thead>
<tr>
<th>Loading</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>.788</td>
<td>7</td>
<td>Receiving your final math grade in the mail.</td>
</tr>
<tr>
<td>.706</td>
<td>6</td>
<td>Waiting to get a math test returned in which you expected to do well.</td>
</tr>
</tbody>
</table>

Because Math Learning Anxiety and Math Grade Anxiety factors are direct consequences of assessments in mathematics, it is not surprising to see higher correlations between Math Test Anxiety and these two factors, than any other factor correlations.
Table 4.12
Factor correlation matrix

<table>
<thead>
<tr>
<th>Factor</th>
<th>Numerical Anxiety</th>
<th>Math Test Anxiety</th>
<th>Math Learning Anxiety</th>
<th>Math Grade Anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerical Anxiety</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Test Anxiety</td>
<td>.386</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math Learning Anxiety</td>
<td>.593</td>
<td>.672</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>Math Grade Anxiety</td>
<td>.422</td>
<td>.673</td>
<td>.570</td>
<td>1.000</td>
</tr>
</tbody>
</table>
Math Anxiety as Measured by MARS-Brief

The mean MARS-Brief score was 65.8 and the standard deviation was 20.7. As previously mentioned, the maximum possible score on the MARS-Brief was 150; therefore the fractional mean (with respect to the total score) was 0.439. The average scores on the MARS-Brief were compared for male and female students by using an independent t-test. The mean math anxiety score for females was $72.12$ ($SD = 21.81$), while for males the mean was lower, $61.88$ ($SD = 19.00$). This difference in the means was statistically significant at $t(471) = 5.380, p < 0.05$.

The relationships between math anxiety (as measured by the MARS-Brief) and the proposed predictors (ACT, age, time without mathematics, math course, and perceived parent and perceived teacher attitudes toward mathematics) were examined by computing corresponding correlations, more specifically Pearson product-moment correlation coefficients for each gender. It needs to be noted that data from the participants who had SAT scores instead of ACT were still included in the analyses. The SAT scores were converted to ACT scores according to the conversion chart provided in Appendix G. The distributions of the ACT
scores for female and male students are shown in Figure 4.19 and 4.20 respectively.

![Histogram of ACT scores for females]

**Figure 4.19.** Distribution of the ACT scores for females.
Figure 4.20. Distribution of the ACT scores for males.

It can be seen from Table 4.13 that the only correlations with math anxiety that were not statistically significant for female students were the ones with perceived father attitudes toward mathematics and math course.
Table 4.13

Correlations between predictors and math anxiety for females

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Pearson Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>Statistically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>-0.192</td>
<td>0.016</td>
<td>Yes</td>
</tr>
<tr>
<td>Age</td>
<td>0.182</td>
<td>0.019</td>
<td>Yes</td>
</tr>
<tr>
<td>PMATM</td>
<td>-0.170</td>
<td>0.022</td>
<td>Yes</td>
</tr>
<tr>
<td>PFATM</td>
<td>-0.110</td>
<td>0.141</td>
<td>No</td>
</tr>
<tr>
<td>PTATM</td>
<td>-0.238</td>
<td>0.001</td>
<td>Yes</td>
</tr>
<tr>
<td>TWM</td>
<td>0.217</td>
<td>0.003</td>
<td>Yes</td>
</tr>
<tr>
<td>MC</td>
<td>-0.034</td>
<td>0.647</td>
<td>No</td>
</tr>
</tbody>
</table>

Statistically significant correlations are in bold.

The scatter plots of these correlations are shown in Figures 4.21 through 4.27.
Figure 4.21. Correlation between ACT and math anxiety for females. ACT scores and math anxiety levels of female students are negatively correlated. Lower ACT scores correspond to higher levels of math anxiety among females.
Figure 4.22. Correlation between age and math anxiety for females. There is a weak, but statistically significant correlation between age and math anxiety levels of female students. Older female students are more likely to experience math anxiety than their younger counterparts.
Figure 4.23. Correlation between perceived mother attitude toward mathematics and math anxiety for females. Perceived mother attitude toward mathematics is negatively related with math anxiety levels of female students. Female students who perceived their mothers to have positive attitude toward mathematics are less likely to exhibit high math anxiety levels in college.
Figure 4.24. Correlation between perceived father attitude toward mathematics and math anxiety for females. Perceived father attitude toward mathematics did not appear to be significantly related to math anxiety levels of female students.
Figure 4.25. Correlation between perceived teacher attitudes toward mathematics and math anxiety for females. Perceived teacher attitude toward mathematics is negatively related to math anxiety levels of female students, indicating that those females who perceived their teachers to have positive attitudes toward mathematics are less likely to become math anxious in college.
Figure 4.26. Correlation between time without mathematics and math anxiety for females. Time without mathematics was found to be a weak, but statistically significant predictor of math anxiety among female students. The positive relationship indicates that female students who waited longer to enroll in another math course are likely to suffer from math anxiety.
Figure 4.27: Correlation between math course and math anxiety for females. What math course female students were enrolled in did not appear to play any role in their math anxiety levels.

In order to include the ordinal variables (time without mathematics and section) in regression analyses, these data points were coded according to the schemes given in Tables 4.14 and 4.15 respectively.
Table 4.14
Coding for the time without mathematics variable

<table>
<thead>
<tr>
<th>Last time a math course was completed</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last semester</td>
<td>1</td>
</tr>
<tr>
<td>Approximately 1 year ago</td>
<td>2</td>
</tr>
<tr>
<td>Approximately 2 years ago</td>
<td>3</td>
</tr>
<tr>
<td>Approximately 3 years ago</td>
<td>4</td>
</tr>
<tr>
<td>Approximately 4 years ago</td>
<td>5</td>
</tr>
<tr>
<td>More than 5, but less than 10 years ago</td>
<td>6</td>
</tr>
<tr>
<td>10 years ago or longer</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.15
Coding for the math course variable

<table>
<thead>
<tr>
<th>Math course</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate Algebra</td>
<td>1</td>
</tr>
<tr>
<td>Excursions in Mathematics</td>
<td>2</td>
</tr>
<tr>
<td>College Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Precalculus</td>
<td>4</td>
</tr>
<tr>
<td>Calculus with Business Applications</td>
<td>5</td>
</tr>
<tr>
<td>Analytic Geometry - Calculus I</td>
<td>6</td>
</tr>
<tr>
<td>Analytic Geometry - Calculus II</td>
<td>7</td>
</tr>
</tbody>
</table>
For male students, however, the only statistically significant correlations with math anxiety were with the ACT scores and perceived father attitudes toward mathematics, as indicated in Table 4.16.

Table 4.16

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Pearson Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>Statistically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>-0.252</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Age</td>
<td>0.001</td>
<td>0.983</td>
<td>No</td>
</tr>
<tr>
<td>PMATM</td>
<td>-0.028</td>
<td>0.632</td>
<td>No</td>
</tr>
<tr>
<td>PFATM</td>
<td>-0.123</td>
<td>0.035</td>
<td>Yes</td>
</tr>
<tr>
<td>PTATM</td>
<td>-0.084</td>
<td>0.153</td>
<td>No</td>
</tr>
<tr>
<td>TWM</td>
<td>0.036</td>
<td>0.537</td>
<td>No</td>
</tr>
<tr>
<td>MC</td>
<td>-0.113</td>
<td>0.054</td>
<td>No</td>
</tr>
</tbody>
</table>

Statistically significant correlations are in bold.

The scatter plots of these correlations are given in Figures 4.28 through 4.34.
Figure 4.28. Correlation between ACT and math anxiety for males. There was a weak, but statistically significant relationship between the ACT scores and math anxiety levels of male students. Male students who scored higher on math section of ACT were less likely to exhibit math anxiety than their counterparts who scored lower on the math achievement test.
Figure 4.29. Correlation between age and math anxiety for males. There was no statistically significant relationship between age and math anxiety levels of male students.
Figure 4.30: Correlation between perceived mother attitude toward mathematics and math anxiety for males. Perceived mother attitude toward mathematics did not appear to be a significant predictor of math anxiety levels of male students.
Figure 4.31. Correlation between perceived father attitude toward mathematics and math anxiety for males. Perceived father attitudes toward mathematics was negatively correlated with math anxiety levels of male students. This indicated that male students who did not perceive their fathers to have positive attitude toward mathematics were likely to suffer from math anxiety in college.
Figure 4.32. Correlation between perceived teacher attitude toward mathematics and math anxiety for males. Perceived teacher attitude toward mathematics was not found to be a significant predictor of math anxiety levels in male students.
Figure 4.33. Correlation between time without mathematics and math anxiety for males. Time passed since the last time male students took math courses was not related to levels of math anxiety among this part of the selected sample.
Figure 4.34. Correlation between math course and math anxiety for males. Math courses that male students were enrolled in were not significantly related to their levels of math anxiety.
Means and Correlations: Numerical Anxiety and Math Test Anxiety

Means: Numerical Anxiety and Math Test Anxiety

The mean scores on two major subscales of the MARS-Brief, Numerical Anxiety and Math Test Anxiety, were 22.1 and 18.1 with standard deviations of 9.5 and 6.0 respectively. The maximum scores on the Numerical Anxiety and the Math Test Anxiety subscales were 70 and 30, respectively. Therefore, the fractional mean scores were 0.316 for the Numerical Anxiety and 0.603 Math Test Anxiety subscales. To investigate a relationship between the scores on two subscales, their means were compared using a dependent t-test. Because the two subscales were comprised of a different number of items, we considered their item means, rather than subscale averages. The average item score on the Numerical Anxiety subscale was 1.68 ($SD = 0.68$), while the average item score on the Math Test Anxiety subscale was 3.02 ($SD = 1.00$). Results from a dependent t-test indicate that this difference was statistically significant, $t(472) = 32.716, p < .001$.

The means on the two subscales were compared between male and female students by using independent t-tests. The mean on the Numerical Anxiety subscale for female students
was 24.29 ($SD = 10.60$), while the average score for male students was 20.78 ($SD = 8.56$), shown in Figure 4.35. The difference between the means was statistically significant at $t(471) = 3.947$, $p < 0.05$.

![Figure 4.35](image)

Figure 4.35. Means on the numerical anxiety subscale based on gender. Female students scored significantly higher on the numerical anxiety subscale than their male counterparts.

The results from an independent t-test indicated that the difference between the means on the Math Test Anxiety subscale was statistically significant at $t(471) = 4.986$, $p <$
The average score on this subscale for female students was 19.84 \((SD = 5.87)\), while for males it was 17.09 \((SD = 5.88)\), shown in Figure 4.36.

Figure 4.36: Means on the math test anxiety subscale based on gender. Female students scored significantly higher on the math test anxiety subscale than their male counterparts.

Correlations: Numerical Anxiety and Math Test Anxiety

To understand the relationships between the proposed predictors of math anxiety and its dominant dimensions, it is necessary to look at the correlations between the scores on the subscales corresponding to two major dimensions and
the predictors. This is also required in order to see if there is a stronger correlation between the predictors and the measured construct, math anxiety or its dominant dimensions: Numerical Anxiety and Math Test Anxiety.

One of the main goals of the current study was to determine if there are gender differences in the above mentioned relationships. Therefore, the correlations were investigated based on gender. As shown in Table 4.17, there were weak, but statistically significant correlations between Numerical Anxiety and ACT, time without mathematics, perceived mother, and teacher attitude toward mathematics for female students.

Table 4.17

Correlations between predictors and numerical anxiety for females

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Pearson Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>Statistically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>-0.212</td>
<td>0.008</td>
<td>Yes</td>
</tr>
<tr>
<td>Age</td>
<td>0.125</td>
<td>0.110</td>
<td>No</td>
</tr>
<tr>
<td>PMATM</td>
<td>-0.162</td>
<td>0.029</td>
<td>Yes</td>
</tr>
<tr>
<td>PFATM</td>
<td>-0.116</td>
<td>0.120</td>
<td>No</td>
</tr>
<tr>
<td>PTATM</td>
<td>-0.232</td>
<td>0.002</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Statistically significant correlations are in bold.

The scatterplots of these correlations are shown in Figures 4.37 – 4.43.

Figure 4.37. Correlation between ACT and numerical anxiety for females. ACT and numerical anxiety levels of female students are negatively correlated, indicating that female students who scored lower on math section of ACT exhibit more numerical anxiety in college.
Figure 4.38. Correlation between age and numerical anxiety for females. There was no significant relationship between age and numerical anxiety of female students. This implies that age is not a significant predictor of numerical anxiety in females.
Figure 4.39. Correlation between perceived mother attitude toward mathematics and numerical anxiety for females. Perceived mother attitude toward mathematics was found to be a significant predictor of numerical anxiety in female students. This indicates that those females who perceived their mothers to have positive attitudes toward mathematics were less likely to be math anxious in college.
Figure 4.40. Correlation between perceived father attitude toward mathematics and numerical anxiety for females. There was no statistically significant correlation between perceived father attitude toward mathematics and numerical anxiety levels of female students.
Figure 4.41. Correlation between perceived teacher attitude toward mathematics and numerical anxiety for females. Perceived teacher attitude toward mathematics was negatively correlated with numerical anxiety in female students, suggesting that female students who did not perceive their teachers to have positive attitude toward mathematics were more likely to experience higher levels of numerical anxiety.
Figure 4.42. Correlation between time without mathematics and numerical anxiety for females. Correlation between time without mathematics and numerical anxiety levels for female students was weak, but statistically significant. The positive relationship between these variables indicates that females who allow for longer gaps between their math course exhibit more numerical anxiety, than the ones who enroll in mathematics course more regularly.
Figure 4.43. Correlation between math course and numerical anxiety for females. What math course female students were enrolled in did not appear to play a significant role in the development of their numerical anxiety.

As shown in Table 4.18, while a statistically significant correlation between numerical anxiety and ACT was also present for male students, the only other significant correlations were with perceived father attitude toward mathematics and math course.
Table 4.18: Correlations between predictors and numerical anxiety for males

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Pearson Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>Statistically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>-0.277</td>
<td>0.000</td>
<td>Yes</td>
</tr>
<tr>
<td>Age</td>
<td>-0.063</td>
<td>0.295</td>
<td>No</td>
</tr>
<tr>
<td>PMATM</td>
<td>-0.023</td>
<td>0.696</td>
<td>No</td>
</tr>
<tr>
<td>PFATM</td>
<td>-0.117</td>
<td>0.046</td>
<td>Yes</td>
</tr>
<tr>
<td>PTATM</td>
<td>-0.093</td>
<td>0.114</td>
<td>No</td>
</tr>
<tr>
<td>TWM</td>
<td>0.014</td>
<td>0.812</td>
<td>No</td>
</tr>
<tr>
<td>MC</td>
<td>-0.213</td>
<td>0.000</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Statistically significant correlations are in bold.

Figures 4.44-4.50 give visual representations of these relationships.
Figure 4.44. Correlation between ACT and numerical anxiety for males. Scores on the math portion of the ACT were negatively correlated with numerical anxiety levels of male students. This suggests that male students who score higher on the math portion of the ACT are less likely to be math anxious than their counterparts who score lower.
Figure 4.45. Correlation between age and numerical anxiety for males. There was no significant relationship between age and numerical anxiety of male students.
Figure 4.46. Correlation between perceived mother attitude toward mathematics and numerical anxiety for males. Perceived mother attitude toward mathematics did not appear to be a significant predictor of numerical anxiety levels of male students.
Figure 4.47: Correlation between perceived father attitude toward mathematics and numerical anxiety for males.

Perceived father attitude toward mathematics was negatively correlated with numerical anxiety levels of male students, suggesting that male students who perceived their fathers to have positive attitude toward mathematics did not appear to be math anxious in college.

\[ y = -0.0889x + 24.617 \]

\[ R^2 = 0.0101 \]
Figure 4.48. Correlation between perceived teacher attitude toward mathematics and numerical anxiety for males. Perceived teacher attitude toward mathematics was not found to be a significant predictor of numerical anxiety of male students.
Figure 4.49. Correlation between time without mathematics and numerical anxiety for males. There was no statistically significant correlation between time without mathematics and numerical anxiety of male students.
Figure 4.50. Correlation between math course and numerical anxiety for males. Section of math course was negatively correlated with numerical anxiety of male students. Students in higher level mathematics course had lower levels of numerical anxiety than their counterparts in lower level courses.

The same relationships were examined between the predictors and math test anxiety. The only statistically significant relationship for females was discovered between math test anxiety and time without mathematics, as shown in Table 4.19.
Table 4.19

Correlations between predictors and math test anxiety for females

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Pearson Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>Statistically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>-0.046</td>
<td>0.564</td>
<td>No</td>
</tr>
<tr>
<td>Age</td>
<td>0.113</td>
<td>0.146</td>
<td>No</td>
</tr>
<tr>
<td>PMATM</td>
<td>-0.124</td>
<td>0.095</td>
<td>No</td>
</tr>
<tr>
<td>PFATM</td>
<td>-0.033</td>
<td>0.657</td>
<td>No</td>
</tr>
<tr>
<td>PTATM</td>
<td>-0.145</td>
<td>0.052</td>
<td>No</td>
</tr>
<tr>
<td>TWM</td>
<td>0.202</td>
<td>0.007</td>
<td>Yes</td>
</tr>
<tr>
<td>MC</td>
<td>0.074</td>
<td>0.321</td>
<td>No</td>
</tr>
</tbody>
</table>

Statistically significant correlations are in bold.

The scatterplots given in Figures 4.51-4.57 show correlations between math test anxiety and the predictor variables for female students.
Figure 4.51. Correlation between ACT and math test anxiety for females. There was no significant relationship between the scores on the math portion of the ACT and math test anxiety levels of female students.
Figure 4.52: Correlation between age and math test anxiety for females. Age was not found to be a statistically significant predictor of math test anxiety of female students.
Figure 4.53. Correlation between perceived mother attitude toward mathematics and math test anxiety for females. Perceived mother attitude toward mathematics was not significantly correlated to math test anxiety levels of female students.
Figure 4.54. Correlation between perceived father attitude toward mathematics and math test anxiety for females. Perceived father attitude toward mathematics was not significantly correlated to math test anxiety levels of female students.
Figure 4.55. Correlation between perceived teacher attitude toward mathematics and math test anxiety for females. Perceived teacher attitude toward mathematics was not significantly correlated with math test anxiety levels of female students.
Figure 4.56. Correlation between time without mathematics and math test anxiety for females. Time without mathematics was positively correlated with math test anxiety levels of female students, indicating that female students who allowed for longer time periods between their mathematics courses were likely to experience higher levels of math test anxiety.
For males, however, there were no significant relationships between math test anxiety and any of the proposed predictors. The statistical details for these investigations are given in Table 4.20 and the corresponding scatterplots are given in Figures 4.58 - 4.64.
Table 4.20: Correlations between predictors and math test anxiety for males

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Pearson Coefficient</th>
<th>Sig. (2-tailed)</th>
<th>Statistically Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>-0.086</td>
<td>0.161</td>
<td>No</td>
</tr>
<tr>
<td>Age</td>
<td>0.017</td>
<td>0.784</td>
<td>No</td>
</tr>
<tr>
<td>PMATM</td>
<td>-0.003</td>
<td>0.960</td>
<td>No</td>
</tr>
<tr>
<td>PFATM</td>
<td>-0.006</td>
<td>0.264</td>
<td>No</td>
</tr>
<tr>
<td>PTATM</td>
<td>-0.062</td>
<td>0.289</td>
<td>No</td>
</tr>
<tr>
<td>TWM</td>
<td>0.055</td>
<td>0.348</td>
<td>No</td>
</tr>
<tr>
<td>MC</td>
<td>0.065</td>
<td>0.265</td>
<td>No</td>
</tr>
</tbody>
</table>

Statistically significant correlations are in bold.
Figure 4.58: Correlation between ACT and math test anxiety for males. There was no statistically significant relationship between ACT and math test anxiety levels for male students.
Figure 4.59. Correlation between age and math test anxiety for males. There was no statistically significant relationship between age and math test anxiety levels for male students.
Figure 4.60. Correlation between perceived mother attitude toward mathematics and math test anxiety for males. There was no statistically significant relationship between perceived mother attitude toward mathematics and math test anxiety levels for male students.
Figure 4.61. Correlation between perceived father attitude toward mathematics and math test anxiety for males. There was no statistically significant relationship between perceived father attitude toward mathematics and math test anxiety levels for male students.
Figure 4.62. Correlation between perceived teacher attitude toward mathematics and math test anxiety for males. There was no statistically significant relationship between perceived teacher attitude mathematics and math test anxiety levels for male students.
Figure 4.63. Correlation between time without mathematics and math test anxiety for males. There was no statistically significant relationship between time without mathematics and math test anxiety levels for male students.
Figure 4.64. Correlation between math course and math test anxiety for males. There was no statistically significant relationship between math course and math test anxiety levels for male students.

Multiple Regression Analysis

To identify the predictors of math anxiety, we performed an ordinary stepwise multiple regression analysis. Multiple regression analysis is a method used in
the situation where it is assumed that there are several independent variables and one dependent variable (Norman and Streiner, 2008). In the current study the dependent variable is math anxiety (more specifically a score on the MARS-Brief which presumably measures math anxiety) and dependent variables are math portion of ACT score, age, course section, time without mathematics, perceived mother, father, and teacher attitudes toward mathematics, as described in Table 4.21.

Table 4.21
Dependent and independent variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variables</td>
<td></td>
</tr>
<tr>
<td>Math Anxiety</td>
<td>MA</td>
</tr>
<tr>
<td>Math portion of ACT score</td>
<td>ACT</td>
</tr>
<tr>
<td>Age of participant</td>
<td>AGE</td>
</tr>
<tr>
<td>Time in years passed since completing a math course</td>
<td>TWM</td>
</tr>
<tr>
<td>Mother influence in mathematics</td>
<td>MI</td>
</tr>
<tr>
<td>Father influence in mathematics</td>
<td>FI</td>
</tr>
</tbody>
</table>

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In an ordinary stepwise multiple regression independent variables are added to the regression model in the order of their power to explain additional variance. If an independent variable is not adding to the variance, meaning no additional prediction is gained by including it in the model, then that variable will be eliminated as a predictor. This method is called ordinary because all the responsibility for the order of selecting and potentially excluding independent variables is given to the computer (Norman and Streiner, 2008).

There were two independent models of math anxiety developed in the current study; one for each gender. Multiple regression analysis of data for female students revealed two statistically significant predictors: time without mathematics and perceived teacher attitude toward mathematics. The correlation coefficients for this model are given in Table 4.22.
Table 4.22

Coefficients of math anxiety model for female students.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>90.88</td>
<td>12.05</td>
<td>7.55</td>
<td>0.000</td>
</tr>
<tr>
<td>TWM (F)</td>
<td>4.52</td>
<td>1.54</td>
<td>2.94</td>
<td>0.004</td>
</tr>
<tr>
<td>PTATM (F)</td>
<td>-0.55</td>
<td>0.22</td>
<td>-2.50</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Therefore, the multiple regression model of math anxiety of female students is given in Equation 4.1 ($r = 0.334; r^2 = 0.112$).

\[ MA(F) = 4.52 \text{TWM}(F) - 0.55 \text{PTATM}(F) + 90.88 \]  

For male students, multiple regression model indicated that the only statistically significant predictor of math anxiety was ACT score, with coefficients given in Table 4.23.

Table 4.23

Coefficients of math anxiety model for male students.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>87.12</td>
<td>6.12</td>
<td>14.24</td>
<td>0.000</td>
</tr>
<tr>
<td>ACT (M)</td>
<td>-1.10</td>
<td>0.26</td>
<td>-4.23</td>
<td>0.000</td>
</tr>
</tbody>
</table>
Therefore, the multiple regression model of math anxiety of male students is presented in Equation 4.2 \( (r = 0.252; r^2 = 0.063) \).

\[
MA(M) = -1.10 \text{ ACT (M)} + 87.12
\]  

(4.2)

To determine if the proposed predictors were similarly related to two major dimensions underlying math anxiety as measured by the MARS-Brief, the same analyses were performed with dependent variables being numerical anxiety (NA) and math test anxiety (TA).

For female students, multiple regression analysis indicated that significant predictors of numerical anxiety were time without mathematics and perceived teacher attitude toward mathematics, as shown in Table 4.24.

**Table 4.24**

Coefficients of numerical anxiety model for female students.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>34.78</td>
<td>5.71</td>
<td>6.10</td>
<td>0.000</td>
</tr>
<tr>
<td>PTATM (F)</td>
<td>-0.28</td>
<td>0.10</td>
<td>-2.74</td>
<td>0.007</td>
</tr>
<tr>
<td>TWM (F)</td>
<td>1.98</td>
<td>0.73</td>
<td>2.71</td>
<td>0.007</td>
</tr>
</tbody>
</table>
Mathematically, this can be expressed by Equation 4.3 ($r = 0.334; r^2 = 0.111$).

$$NA(F) = 1.98 TWM(F) - 0.28 PTATM(F) + 34.78 \quad (4.3)$$

However, the only predictor of math test anxiety of female students was time without mathematics. The coefficients are provided in Table 4.25 and mathematical model is given in Equation 4.4 ($r = 0.191; r^2 = 0.036$).

$$TA(F) = 1.02 TWM(F) + 17.80 \quad (4.4)$$

### Table 4.25

Coefficients of math test anxiety model for female students.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>17.80</td>
<td>0.84</td>
<td>21.27</td>
<td>0.000</td>
</tr>
<tr>
<td>TWM(F)</td>
<td>1.02</td>
<td>0.42</td>
<td>2.42</td>
<td>0.017</td>
</tr>
</tbody>
</table>

For male students, the results were notably different. The predictors of numerical anxiety of male students were ACT and age, as shown in Table 4.26. The model is given by Equation 4.5 ($r = 0.302; r^2 = 0.091$).

$$NA(M) = -0.61 ACT(M) - 0.34 AGE(M) + 41.65 \quad (4.5)$$
Table 4.26
Coefficients of numerical anxiety model for male students.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>41.65</td>
<td>4.90</td>
<td>8.50</td>
<td>0.000</td>
</tr>
<tr>
<td>ACT(M)</td>
<td>-0.61</td>
<td>0.12</td>
<td>-5.11</td>
<td>0.000</td>
</tr>
<tr>
<td>AGE(M)</td>
<td>-0.34</td>
<td>0.17</td>
<td>-2.06</td>
<td>0.041</td>
</tr>
</tbody>
</table>

However, age of students was no longer a predictor in math test anxiety for males. As shown in Table 4.27, the two predictors that were identified were course section and ACT score. The multiple regression model is given by Equation 4.6 \( r = 0.235; r^2 = 0.055 \).

\[
TA(M) = 0.82 \text{MC}(M) - 0.32 \text{ACT}(M) + 20.65 \tag{4.6}
\]

Table 4.27
Coefficients of math test anxiety model for male students.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>20.65</td>
<td>1.94</td>
<td>10.66</td>
<td>0.000</td>
</tr>
<tr>
<td>MC (M)</td>
<td>0.82</td>
<td>0.22</td>
<td>3.66</td>
<td>0.000</td>
</tr>
<tr>
<td>ACT(M)</td>
<td>-0.32</td>
<td>0.10</td>
<td>-3.25</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Summary

The collected data was analyzed using bivariate regression to examine relationships between the proposed predictors and math anxiety. Also investigated were the relationships between these predictors and two major dimensions of math anxiety, Numerical Anxiety and Math Test Anxiety. In order to include the combined effects of the predictors on these constructs for both male and female students, multiple regression models were developed for each gender.

In the next chapter, we interpret the results and examine the relationships between math anxiety and its proposed predictors. Furthermore, we look into the significance of the factor analysis results and how they impact not only the answers to the posed research questions, but also the direction of the current research.
CHAPTER V
DISCUSSION

The purpose of the current study was to investigate gender differences in the way certain potential predictors impact math anxiety experienced by college students. Due to inconsistencies in the prior research reported in the literature, it was important to look into the relationship between gender and math anxiety as a function of several predictors. While there has been no consensus reached regarding their effects on math anxiety, the predictors that have been most frequently examined include math preparedness, time without mathematics, and age. Also believed to be significant are attitudes of parents and teachers toward mathematics as perceived by the students.

In this study, the math preparedness was measured by the scores on the math portion of the ACT and the level of the math course the participants were enrolled in. The distributions of the ACT scores for females and males were given in Figures 4.19 and 4.20, respectively.
Time without mathematics was estimated using the time measured in years since the last completed math course, and the distributions are shown in Figure 4.6 for female and 4.7 for male students.

Perceived parent and teacher attitudes toward mathematics were measured by the corresponding subscales that were part of the demographic questionnaire administered to the participants. These subscales were designed to measure students’ perceptions of their parents’ and teachers’ attitudes toward mathematics.

Before the construct of math anxiety could be closely examined in relation to these predictors, it was necessary to understand the predictors themselves and investigate relationships, if any, between them. Keeping in mind that the main emphasis of this study was on gender differences, all relationships between the independent variables (predictors) were investigated separately for each gender.

**Predictors of Math Anxiety**

*Age and Time Without Mathematics (TWM)*

Age of the participants was measured in years and for the selected sample it ranged between 17 and 46, with the average age of 20.1 years. The distributions of age for
female and male students were similar, as shown in Figures 4.2 and 4.3, with means of 20.25 (SD = 4.24) and 20.12 (SD = 3.49) respectively.

As indicated above, time without mathematics was measured in years passed since the last mathematics course was completed. It can be seen from Figure 4.5 and Table 4.3 that most students who participated in the current study completed a mathematics course either one semester or two semesters prior to participating in the study.

The analysis of the relationship between age and time without mathematics revealed that there was a statistically significant correlation between the two variables for female, but not male students. This correlation between age and time without mathematics for female students was shown in Figure 4.8. These results indicated that older female students were more likely to allow for longer time periods between math courses they were enrolled in than their younger counterparts. The presence of the significant relationship between age of female students and time without mathematics, and a lack of the same relationship for male students could be explained by the findings that indicated that females were likely to be more math anxious than their male counterparts (Betz, 1978; Khatoon and
Female students also acknowledged more negative reactions toward mathematics (Wigfield and Meece, 1988). These negative reactions coupled with math anxiety may be some of the causes of math avoidance behavior in females, especially older ones.

*Perceived parent attitude toward mathematics (PPATM)*

Perceived parent attitude toward mathematics (PPATM) was presumed to be an important predictor of math anxiety. However, before investigating the relationship between perceived parent attitude toward mathematics and math anxiety, it was necessary to determine if the PPATM variable was actually comprised of two related, but distinct variables: perceived mother attitude toward mathematics (PMATM) and perceived father attitude toward mathematics (PFATM).

The possible scores on the corresponding subscales of the demographic questionnaire pertaining to students’ perceptions of their parents’ attitudes toward mathematics could each range from 13 (minimum) to 65 (maximum). The means on the PMATM subscales for males and females were comparable at 41.66 ($SD = 6.62$) and 41.25 ($SD = 8.42$), with their
distributions shown in Figures 4.12 and 4.9 respectively. For the PFATM subscale, the means for male and female students were 44.40 \( (SD = 9.59) \) and 43.03 \( (SD = 11.23) \), with their distributions shown in Figures 4.13 and 4.10 respectively.

To better understand how these variables were related for both genders, the means on the corresponding demographic questionnaire subscales were compared statistically. There was no significant difference between PMATM and PFATM for females. This suggested that female students perceived their mothers and fathers to have similar attitudes toward mathematics. For male students, however, the differences between the scores on the PMATM and PFATM subscales were significantly different. This suggested that males perceived their fathers to have a more positive attitude toward mathematics than their mothers.

Weak, but statistically significant correlations between PMATM and PFATM for both genders were shown in Figures 4.11 and 4.14. The findings suggested that if students perceived one of their parents to have a positive attitude toward mathematics, they were likely to perceive it coming from the other parent as well. The lack of a strong correlation between the two variables (PMATM and
PFATM) for either gender supported the need for two distinct independent variables to be included in the further analysis of math anxiety rather than just including a combined perceived parent attitude toward mathematics. Additionally, further analysis showed that these two variables were not correlated with age for either gender, suggesting that student perceptions of their parents’ attitudes toward mathematics did not change significantly over time.

Perceived Teacher Attitude Toward Mathematics (TPATM)

Recalling the effect that math anxiety supposedly had on teachers and the way teachers’ attitudes, beliefs, and their math anxiety levels affected their students (Emenaker, 1996; Vinson, 2001), it was important to closely look into perceived teacher attitude toward mathematics (PTATM). The distributions of the scores on the subscale on the demographic questionnaire measuring perceived teacher attitude toward mathematics for female and male students were given in Figures 4.15 and 4.16 respectively. These scores had a possible range of 13 to 65. The average score on this subscale for female students was 50.59 ($SD = 7.70$) and for male students, 52.80 ($SD = 7.23$). The comparison of the
means suggested that male students were more likely to perceive their teachers to have positive attitude toward mathematics than their female counterparts. It needs to be noted that it cannot be deduced from the current study if teachers did indeed have more positive attitude toward mathematics expressed to their male rather than female students, or if that was just the students’ perceptions.

It would also be interesting to determine if gender of an authority figure, such as teacher or parent, was related to the attitude toward mathematics they express before male and female students. Simply put, do male students perceive their male teachers to have more positive attitudes toward mathematics than their female teachers? And do both male and female students have comparable perceptions of attitudes toward mathematics expressed by their female teachers? The answers to these questions are very important considering that the most positive attitudes toward mathematics for both genders appeared to be expressed, not by their parents, but rather by their teachers. This can be seen from Figure 4.17 and Table 4.4, where the scores on the PTATM subscale were significantly higher than the PMATM and PFATM scores for both males and females.
Correlations: Math Anxiety

Math anxiety of the participants was measured by the MARS-Brief. The mean score on MARS-Brief was 65.8 and the standard deviation was 20.7. Considering that the minimum score on the scale was 30 and maximum 150, the mean score represented only 43.9% of the maximum attainable score on the instrument. One of the possible explanations of this result was that the selected sample was not very math anxious. The low scores on the MARS-Brief in this study, in addition to low scores on the MARS and other MARS based instruments reported in the literature (Bessant, 2005; Brush, 1978; Gresham, 2007; Hopko et al., 2003; Hunsley, 1987; Malinksy, Ross, Pannells, and McJunkin, 2006; Morris, Kellaway, and Smith, 1978; Plake and Parker, 1982; Resnick, Viehe, and Segal, 1982; Richardson and Suinn, 1972; Vinson, 2001; Woodard, 2004), could also be interpreted to cast a shadow of doubt regarding the actual existence of this condition among the participating samples, or the sensitivity of MARS to this construct.

The mean score on the MARS-Brief was significantly higher for female students than male. The average scores were 72.12 and 61.88 for females and males respectively.
This suggested that female students exhibited more math anxiety than their male counterparts. These findings were in agreement with multiple observations reported in the literature that implied that there were gender differences in levels of math anxiety experienced by college students (Betz, 1978; Hembree, 1990; Khatoon and Mahmood, 2010; Llabre and Suarez, 1985; Malinsky et al., 2006; Richardson and Suinn, 1972). However, considering that even the math anxiety average score for female students (the highest of the two) was only at 48.08% of the total possible MARS-Brief score, one cannot help but wonder, just how math anxious was the sample, or alternatively, how useful the instrument is in measuring the construct, and how this might affect the further analysis, as addressed later in this chapter.

Correlations: Math Anxiety for Female Students

Before attempting to prove or refute the research hypotheses, the individual correlations between math anxiety and its proposed predictors were examined. These analyses allowed us to be able to identify not only the impact of each predictor on the construct, but also determine (when used in the multiple regression analysis)
if this impact is affected by the presence of any of the other proposed predictors. It can be seen from Table 4.13, and Figures 4.27 and 4.24 that the only relationships between math anxiety levels of female students and the proposed predictors that were not statistically significant were the ones between math anxiety and math course, and math anxiety and perceived father attitude toward mathematics. As previously noted, math course corresponded to a math class the participants were enrolled in during the study. A lack of significant correlation between math course and math anxiety of female students was relatively surprising considering the finding of Betz (1978) who demonstrated that students in higher levels of mathematics experienced less math anxiety than students enrolled in developmental or lower level mathematics courses at the university. Of course, in the current study, considering relatively low average scores on the math anxiety measure, it may be more challenging to isolate the effects that certain predictors have on this phenomenon, especially if these affects are not as strong and dominating, which may be the case with math course. Alternatively, changes in student demographics, life experiences, etc, may have
diminished the sensitivity of the instrument since its original construction in 1972.

The correlations between math anxiety levels of female students and remaining predictors (ACT, age, PMATM, PTATM, and time without mathematics) were weak, but nevertheless statistically significant. As shown in Figure 4.21, the scores on the math portion of the ACT were negatively related to math anxiety levels, implying that female students who scored low on the math portion of the ACT were more likely to experience math anxiety in college. This was consistent with the findings of Haynes et al. (2004) who also identified ACT scores as significant predictors of this condition in females. Also negatively correlated with math anxiety experienced by female students were perceived mother and perceived teacher attitude toward mathematics, as seen in Figures 4.23 and 4.25 respectively. These findings could be interpreted to suggest that a lack of perceived positive attitude toward mathematics exhibited by mothers and teachers was expected to result in increased math anxiety levels of female students. Interestingly, perceived father attitude toward mathematics did not seem to have a similar effect.
Visual representation of the relationship between math anxiety and age of female students is given in Figure 4.22. It can be seen that the two variables are positively related, suggesting that older female students were more math anxious than their younger counterparts. This observation was consistent with findings reported in the literature (Betz, 1978; Royse and Rompf, 1992). Time without mathematics was also positively correlated with math anxiety of female students. This was an expected outcome considering the previously mentioned positive correlation between age and time without mathematics (see Figure 4.26). The results implied that female students who allowed for longer gaps between completing math courses were likely to experience anxiety related to this discipline.

Correlations: Math Anxiety for Male Students

Investigation of relationships between math anxiety levels of male students and the proposed predictors revealed that there were only two predictors that were significantly correlated with math anxiety levels: ACT and perceived father attitude toward mathematics (PFATM). Analogous to the relationship between ACT and female
students’ math anxiety levels (see Figure 4.21), the ACT scores were negatively correlated to math anxiety of male students (as shown in Figure 4.28). This implied that male students who scored higher on the math portion of the ACT were less likely to be math anxious, then those males who scored lower, which again is aligned with the results reported by Haynes et al. (2004). The trends between ACT scores and math anxiety for males and females found in the current study were in agreement with the findings of Betz (1978) who reported that higher achievement in mathematics, as measured by math ACT scores, was related to lower levels of math anxiety for both genders.

The negative correlation between PFATM and math anxiety of male students was shown in Figure 4.31. It was evident from the findings of the current study that for male students, PFATM was related to their math anxiety levels, while PMATM and PTATM were not significant predictors (Figures 4.30 and 4.32 respectively). These results suggested that male students who perceived their fathers to have positive attitudes toward mathematics, did not exhibit high levels of math anxiety in college. The attitudes toward mathematics that were perceived to be exhibited by mothers and teachers did not appear to play a
significant role in the development of math anxiety in males.

Age of male students was not related to their math anxiety levels, as seen in Figure 4.29. Furthermore, male students who allowed for longer periods without mathematics did not seem to experience any significantly higher math anxiety levels than students who were taking mathematics courses more regularly (see Figure 4.33). What math course male students were enrolled in also did not prove to be an important predictor of math anxiety, as shown in Figure 4.34. As was the case with the relationship between math course and female math anxiety, these findings are inconsistent with the findings reported by Betz (1978).

**Multiple Regression Models: Math Anxiety**

With the exception of ACT and math course, no other proposed predictor had the same type of relationship with math anxiety for both male and female students when studied individually. Therefore, the individual correlations between math anxiety and the proposed predictors suggested gender differences in the impact of these independent variables on math anxiety. However, to fully understand
what factors affected math anxiety in both genders, it was imperative to study a collective, rather than individual, or more specifically, isolated impact of the predictors. To achieve this, multiple regression models were developed for math anxiety levels of both male and female students. These models included only those independent variables (predictors) that provided a significant power of prediction of math anxiety for each gender.

*Multiple Regression Model: Math Anxiety of Females*

When the effects of each predictor of math anxiety were examined individually (The impacts of the predictors on each other were excluded.), perceived father attitude toward mathematics and math course were the only two independent variables that offer no power of prediction of math anxiety of female students. However, the multiple regression model took into account the relationships between the independent variables, and as such, it recognized only two statistically significant predictors of math anxiety of female students: time without mathematics and perceived teacher attitude toward mathematics (as shown in Equation 4.1).
According to this model, math anxiety levels of female students were positively correlated to time passed since the last completed math course, and negatively correlated with perceived teacher attitude toward mathematics. This suggested that the female students who allowed for longer gaps in their mathematical education were likely to become math anxious in college. Additionally, those female students who perceived their teachers to have positive attitude toward mathematics were not as likely to become math anxious. Recalling the findings that suggested that males, rather than females, perceived their teachers to have positive attitudes toward mathematics, it was somewhat expected to see a negative relationship between PTATM and math anxiety levels of female students.

Based on the multiple regression model, math ACT scores, age, perceived parent attitude toward mathematics, and math course did not appear to be significant predictors of math anxiety. This implied that while age, perceived mother attitude toward mathematics, and ACT scores seemed to be correlated with math anxiety levels when examined individually (without taking into the account the presence of other predictors), once the impacts of all predictors (included in this study) were considered, the relationships
between these independent variables and math anxiety levels of female students were no longer significant. This can be explained by the fact that the correlation coefficients between these independent variables and math anxiety levels of females, while statistically significant, were very small, resulting in weak effects that may have ended up being drowned out by the effects of the other predictors included in the multiple regression analysis.

**Multiple Regression Model: Math Anxiety of Males**

The multiple regression model of math anxiety of male students was not perfectly aligned with the findings of individual relationships between the predictors of math anxiety and math anxiety levels. Two significant predictors in individual correlations were ACT and perceived father attitude toward mathematics (see Figures 4.28 and 4.31 respectively). However, according to Equation 4.2, which provided a multiple regression model of math anxiety levels of male students, math anxiety was negatively correlated only with math ACT scores. This suggested that the effect of ACT scores on math anxiety of males was not affected by the impacts of other predictors included in the analysis, while PFATM was impacted, and its individual effect
diminished. Therefore, the only suggested indicator of math anxiety among male students appeared to be math ACT score. More specifically, male students with lower ACT scores were more likely to exhibit higher levels of math anxiety in college than their counterparts who scored higher. Additionally, a lack of significant correlations between perceived mother and father attitude toward mathematics with math anxiety levels of both male and female students was consistent with similar findings of Stuart (2000) who observed no significant relationship between parents’ attitudes, beliefs, or perceptions toward mathematics and levels of math anxiety experienced by their children.

Summary of Multiple Regression Analysis of Math Anxiety

Comparing the multiple regression models for math anxiety of male and female students (given by Equations 4.1 and 4.2) suggested that there were gender differences in the impact of proposed predictors. While math anxiety of female students could be predicted by time passed since the last time a math course was completed and students’ perception of teacher attitude in mathematics, for male students the only significant predictor was ACT score.
Therefore, the null hypothesis given by Equation 3.4 should be rejected in favor of accepting the research hypothesis stating that there are gender differences between the correlations of math anxiety with age, ACT scores, mathematics course, time without mathematics, perceived parent and teacher attitude toward mathematics. While ACT, time without mathematics, and perceived teacher attitude toward mathematics had different impact on math anxiety depending on the gender, the other independent variables, age, math course, and perceived parent attitude toward mathematics, did not appear to have any prediction power regarding math anxiety for either gender.

It should be noted that the very low correlation coefficients of the included independent variables in the multiple regression model, coupled with relatively low mean MARS-Brief scores for both female and male students (48.08% and 41.23% of the maximum score, respectively), may suggest that the inquiry into math anxiety may not end here. Two plausible explanations of these findings may be given. The first one suggests that the selected sample of the participants is simply not very math anxious. This explanation would be somewhat surprising taking into the account the confirmation of the prevalence of math anxiety
on college campuses (Betz, 1978; Khatoon and Mahmood, 2010; Perry, 2004), as well as anecdotal evidence given by the professionals in the field, faculty, advisors, and administrators, who observed anxiety related to mathematics among their students. Furthermore, the sample in the current study was selected from the population consisting of students enrolled in first and second year math courses; groups very likely to experience math anxiety (Betz, 1978).

The second explanation for the observed low scores on the measure of math anxiety involves raising a question of internal validity of the instrument used to measure math anxiety. Although a satisfactory evidence of validity and reliability of MARS and MARS based instruments (such as MARS-Brief) is available in the literature, this forty-year old instrument may no longer be relevant for 21st century college students. If a scale, in this case MARS and MARS based instruments, is a well constructed instrument made up of only relevant items important to assessing the presence of this construct in subjects, then participants with high levels of math anxiety should be responding to the majority of items in such a way as to lead to their having high scores. However, in the current study, the mean item score
of approximately 2, corresponded to a very little anxiety experienced by the students.

As previously noted, MARS-Brief is a MARS based instrument measuring math anxiety as defined by Richardson and Suinn (1972). Similar to its base instrument, the scores on MARS-Brief are expected to be dominated by a single, homogenous factor (Richardson and Suinn, 1972; Suinn and Watson, 2003). To identify dimension underlying math anxiety as measured by MARS-Brief, and to determine which factor dominates the scores as opposed to dominating the construct of math anxiety, factor analysis of MARS-Brief was performed.

**Factor Analysis of MARS-Brief**

Four factors were identified as a result of factor analysis of this instrument: Numerical Anxiety, Math Test Anxiety, Math Learning Anxiety, and Math Grade Anxiety. Having the largest eigenvalue and contributing to the largest percent of the variance (as shown in Table 4.5), Numerical Anxiety and Math Test Anxiety were recognized as two major dimensions dominating the scores of MARS-Brief. These findings were consistent with the results of the
majority of the studies investigating the dimensions underlying math anxiety as measured by MARS or MARS based instruments (Alexander and Cobb, 1989; Alexander and Martray, 1989; Resnick et al., 1982; Rounds and Hendel, 1980; Suinn and Winston, 2003). Surprisingly, a review of the literature on the dimensionality of math anxiety as measured by these instruments revealed a lack of reporting on the part of the studies in the literature on a relationship between the identified factors and the scores on the corresponding subscales.

The last two factors, Math Learning Anxiety and Math Grade Anxiety, were perceived as direct outcomes of Math Test Anxiety. Although Math Grade Anxiety had only two items loading on it, the fact that the brief version of the MARS contained only two questions that pertained to receiving a grade in a math class, and given the close relationship of this factor with Math Test Anxiety, not discarding it from the interpretation of the results was justified. Furthermore, the factor analysis was performed on a modified version of the MARS, and it was the researcher’s belief that if the analysis was performed on the original scale, more items would load on this factor.
The low scores on the Numerical Anxiety subscale, but significantly higher scores on the Math Test Anxiety subscale warrant a further inquiry into whether this is due to a decrease in the usefulness of MARS and MARS-based instruments in measuring math anxiety in 21st century students, or is due to the need for more thorough investigation into the nature of math anxiety and its principal dimensions. For example, if we consider responses on both the Numerical Anxiety and Math Test Anxiety subscales of at least ‘3’, (corresponding to ‘a fair amount’) to be indicators of moderate to high math anxiety, then it is evident that only 31 participants (or 6.55%) seem to be experiencing at least moderate levels of math anxiety, as measured by this instrument. This is consistent with Rounds and Hendel’s (1980) observation that at most 6% of the participants scored high on both MARS derived factor scales (Mathematics Test Anxiety and Numerical Anxiety).

The findings of the current research showed that the anxiety related to manipulation of numbers in everyday settings (corresponding to Numerical Anxiety) was more dominant with respect to the number of items making up the instrument than the one stemming from evaluation of one’s math ability (corresponding to Math Test Anxiety). This was
indicated by a higher eigenvalue and percentage of total variance corresponding to the Numerical Anxiety factor (see Table 4.8). Although the Numerical Anxiety factor dominated the scores, the Math Test Anxiety seemed to be a more prevalent dimension. Significantly different from the average score per item on the Numerical Anxiety subscale, the Math Test Anxiety average score per item indicated that the participants exhibited moderate anxiety when faced with an evaluation of a math task (mean = 3.02), while they experienced no, or at most very little anxiety related to everyday manipulation of numbers (mean = 1.68). It needs to be noted that the average score per item is a ratio of an attained score and maximum score on the scale. In addition, as previously mentioned, a response of ‘1’ on the MARS-Brief corresponds to “not at all” and ‘5’ corresponds to “very much”.

That the scores were significantly higher on the evaluation subscale than on the numerical one implied that college students’ anxiety stemmed, not necessarily from facing a mathematical task, but rather from being evaluated on one. The results of this study support a need for an in-depth investigation of the relationship between math anxiety and test anxiety, and determining if a high
correlation between the two would indicate a strong connection between the two distinct constructs, or just that the two were parts of a larger whole.

The two factors that had the most salient items, Numerical Anxiety and Math Test Anxiety, coincided with the factors identified by Suinn and Winston (2003) who factor analyzed the same instrument. One may expect that the factor dominating the instrument would coincide with the subscale dominating the scores on the instrument. For example, Math Test Anxiety was recognized as the first of three factors extracted as a result of factor analysis performed by Alexander and Martray (1989). That factor had the highest average score per item (2.73) compared to the other two.

It should be noted that the order of extraction of factors corresponds to the ranking of their eigenvalues. For example, if a certain factor is extracted first, then its eigenvalue is the largest one of all. In general, a factor’s eigenvalue corresponds to number of items in an instrument related to that factor. Simply put, higher eigenvalue corresponds to more instrument items pertaining to that factor. This means that a factor with the highest eigenvalue is the most important to the instrument, but not...
necessarily to the construct. More specifically, a subscale corresponding to a factor with the highest eigenvalue may not have the highest average score. This would imply that this factor, while the most relevant to the instrument, is not the most significant to the construct.

For example, the results of a few studies that reported the scores on their subscales indicated that factors with the highest eigenvalues were not necessarily the ones whose corresponding subscales had the highest average scores. The second factor (labeled Evaluation Anxiety) identified in a factor analysis of the MARS (Brush, 1978) had a higher average score per item (ranging from 1.93 to 2.72) than the first factor (labeled Problem-Solving Anxiety) with average score per item between 1.33 and 1.66. Similar results were reported by Morris et al. (1978). Of three factors extracted in their study, the second one, Math Test Anxiety, had the highest average score per item of 2.84 (for sample of students enrolled in a math course) and 3.14 (for sample of students enrolled in a psychology course). Evaluation Anxiety was also identified as the first of three factors extracted by factor analysis of the MARS by Resnick et al. (1982). This factor, however, had a lower average score per item than
the second factor, Social Responsibility Anxiety. Reports of scores on the subscales identified by other researchers would have aided in determining any significant trends between the factors and the subscale scores. Unfortunately, this type of data is scarce in the existing literature.

**Dimensions of Math Anxiety**

In order to determine if there were any gender differences in Numerical Anxiety and Math Test Anxiety, the means on the two subscales were compared statistically. The results indicated that female students exhibited significantly higher levels of numerical anxiety and math test anxiety than their male counterparts. These results were expected considering that the findings of the current work indicated that female students experience higher levels of math anxiety than male students.

As previously mentioned, low (fractional) mean scores can be interpreted as contradictory to claims of the prevalence of math anxiety on college campuses. However, a lack of high scores on math anxiety scales as well as the numerical anxiety subscale when using MARS should not necessarily be interpreted as implying that math anxiety is
not prominent among college student populations. Since many college professionals report anecdotal evidence that students are experiencing significant levels of math anxiety, it may be more likely that the instruments used to assess this condition are no longer valid or that they may not be encompassing all the aspects of what has proven to be a very complex, multidimensional construct.

To fully understand what math anxiety entails, it may be necessary to take this investigation out of the bounds of academia where students’ responses on scales measuring this phenomenon are possibly influenced by feelings of anxiousness related to constructs other than math anxiety. Furthermore, the need for an instrument that will measure not just the commonly accepted dimensions of math anxiety, but also the ones presumably not tapped into by the MARS, may be critical to reaching a full understanding of this important construct.

**Correlations: Dimensions of Math Anxiety**

To determine if the relationships between the proposed predictors of math anxiety and math anxiety levels were maintained in the two major dimensions of this construct, the same correlation and multiple regression analyses
described above were performed for Numerical Anxiety and Math Test Anxiety.

**Numerical Anxiety**

Individual correlations between the proposed predictors and numerical anxiety of female students were similar to correlations between the same predictors and math anxiety levels of female students. It can be seen from Table 4.17 that correlations between ACT, time without mathematics, perceived mother and teacher attitude toward mathematics and numerical anxiety levels were weak, but statistically significant for female students. Similar to the impact these predictors had on math anxiety of female students, ACT scores and the perceived mother and teacher attitude toward mathematics were negatively correlated with numerical anxiety (see Figures 4.37, 4.39, and 4.41 respectively). This suggested that female students who scored high on the ACT or the ones who perceived their mothers or teachers to have positive attitude toward mathematics were less likely to exhibit high levels of math anxiety.

Time without mathematics affected numerical anxiety in the same way that it impacted math anxiety of females
(positively), as shown in Figure 4.42. This finding implied that longer time without mathematics resulted in more numerical anxiety in female students. Age was the only significant predictor of math anxiety that did not seem to impact numerical anxiety levels of female students. Finally, the math course females were enrolled in, as well as perceived father attitude toward mathematics did not affect the levels of numerical anxiety of female students.

The next step in the analysis was to examine the impact of the predictors on numerical anxiety of female students while taking into account the effects of the predictors on each other. Although the correlation coefficients were slightly different in magnitude, the multiple regression model of numerical anxiety of female students aligned with the corresponding model of math anxiety (Equations 4.3 and 4.1 respectively). Time without mathematics and perceived teacher attitude toward mathematics were identified as significant predictors of numerical anxiety in female students. Time without mathematics was positively related to numerical anxiety, while perceived teacher attitude toward mathematics was negatively correlated. The findings suggest that female students who waited longer before taking another
mathematics course were more likely to experience significant amounts of numerical anxiety. This was also true for females who did not perceive their teachers to have positive attitude towards this discipline.

Individual relationships between the predictors and the numerical anxiety of male students were for the most part similar to their relationships with math anxiety (see Table 4.18 and Figures 4.44 through 4.50). The only exception was the math course predictor. While this independent variable was not related to math anxiety, it was a significant predictor of numerical anxiety of male students. Therefore, the higher the level of the math course, the less numerical anxiety was exhibited by males. As shown in Table 4.18, also negatively correlated with numerical anxiety were ACT scores and perceived father attitude toward mathematics. These correlations were shown in Figures 4.44 and 4.47 respectively. Male students who perceived their fathers to have a positive attitude toward mathematics experienced lower levels of numerical anxiety. Low levels of this type of anxiety were also predicted in male students who scored high on the math portion of the ACT.
However, once the impacts of the independent variables on each other were included in the model, the perceived father attitude toward mathematics and the math course students were in were no longer recognized as significant predictors of numerical anxiety. Similar to the model of math anxiety of male students, ACT was still negatively related to levels of numerical anxiety. However, this was no longer the only variable affecting numerical anxiety of male students. It was evident from Equation 4.5 that age appeared to play a relevant role as well. These results imply that older male students were more likely to experience higher levels of numerical anxiety than their younger counterparts.

Math Test Anxiety

Computing correlation coefficients between the proposed predictors and math test anxiety scores for female students indicated only one significant relationship (see Table 4.19). As shown in Figure 4.56, time without mathematics was positively related to math test anxiety. This implies that female students who had longer time periods between math courses experienced more anxiety regarding evaluations of their math tasks. The impacts of
predictors on each other did not have any notable effect on math test anxiety. This was confirmed by the multiple regression model of math test anxiety for female students, given in Equation 4.4. The only significant indicator of female math test anxiety was time without mathematics, while perceived teacher attitude toward mathematics, which seemed to play a significant role in math anxiety and numerical anxiety, was no longer relevant. These findings may be interpreted to suggest that the nature of math test anxiety is different than the nature of math anxiety.

The investigation of individual relationships between each predictor and math test anxiety of male students revealed no significant correlations (as shown in Table 4.20 and Figures 4.58 through 4.64). However, multiple regression analysis of this data recognized ACT and math course as significant predictors (see Equation 4.6). These findings suggested that male students in higher level math courses exhibited lower levels of math test anxiety than their counterparts in lower level courses. It also implied that those male students who scored low on math portion of ACT were more likely to suffer from math test anxiety later in college.
A lack of significant correlations in individual relationships between some of the predictors and the construct, but their presence in the multiple regression model indicates that the impact of those predictors only comes into a full effect when coupled with other potential predictors of math anxiety. For example, as mentioned above, both ACT and math course for male students were not significantly correlated with math test anxiety, as shown in Figures 5.1 and 5.2.

Figure 5.1. Correlation between ACT and math test anxiety for male students.
Figure 5.2. Correlation between math course and math test anxiety for male students.

However, the scatter plot of the relationship between these two independent variables and math test anxiety (see Figure 5.3) reveals, weak, but nonetheless significant correlation.
Figure 5.3. Correlation between the independent variables (ACT and math course) and math test anxiety for male students.

Summary of Dimensions of Math Anxiety

Recalling Equations 4.2, 4.5, and 4.6, it could be concluded that neither the model for numerical anxiety nor math test anxiety of male students aligned with the model of math anxiety. This further strengthened the implication that although these two factors, Numerical Anxiety and Math Test Anxiety, appeared to dominate the math anxiety scores.
for male students, their nature might be conspicuously different, warranting a need for more research into the dimensions of math anxiety.

Comparing multiple regression models for numerical anxiety for males and females implied that there were gender differences in the importance of predictors for this construct. ACT, age, time without mathematics, and perceived teacher attitude in mathematics had different impacts on numerical anxiety with respect to gender. Math course and perceived parent attitudes in mathematics did not seem to be significant predictors of numerical anxiety of males and females. Therefore, the null hypothesis given by Equation 3.5 should be rejected in favor of the research hypothesis that states that there are gender differences between the correlations of numerical anxiety with age, ACT scores, mathematics course, time without mathematics, perceived teacher and parent attitude toward mathematics.

Multiple regression models of math test anxiety for males and females revealed that no predictor affected this construct the same way for both genders. These findings suggested that time without mathematics, math course, and ACT impacted math test anxiety differently based on gender. It follows that the null hypothesis given by Equation 3.6
should be rejected in favor of the research hypothesis that states that there are gender differences between the correlations of math test anxiety with age, ACT scores, mathematics course, time without mathematics, perceived teacher, and parent attitude toward mathematics.

Implications of Research

General Implications

There are direct and indirect implications of this study. Direct implications pertain to the answers to the posed research questions and they are addressed in the summary of the discussion later in this chapter. The existence of indirect implications is a consequence of decades of research, and an abundance of findings that indicate a lack of consensus on the nature and factors underlying math anxiety. Because of this lack it was necessary to try to probe even further into this complex phenomenon.

The construct of math anxiety, initially seen and labeled as number anxiety, has been studied by many researchers. The label “math anxiety” has been used as an umbrella term describing certain behaviors exhibited by individuals identified as suffering from this condition.
However, definitions of math anxiety, although overlapping, are not identical in nature. If anxiety can be described as feelings of tension, fear, and panic when faced with the object of the anxiety, does that indicate that math anxiety corresponds to feelings of tension, fear, and panic when faced with mathematics? And if it does, what does being faced with mathematics truly mean? Does it mean being faced with numbers, or number manipulation; does it mean being faced with a mathematical task, performing one, or being evaluated on one? A lack of answers to these questions imply that definition of math anxiety needs to be revisited, and the behaviors encompassed by this condition need to be specifically stated.

Additionally, the evidence for the existence of this condition (based on the level of math anxiety measured by instruments such as MARS) is surprisingly not as strong as one would have expected. Low scores on MARS-Brief that correspond to almost no numerical anxiety, but a fair amount of test anxiety, suggest that the sample of the participants in this study was not experiencing math anxiety, but rather test anxiety. However, these findings, accompanied by a review of results in literature, are contradictory to anecdotal evidence that strongly supports
the prevalence of this condition among college students. Furthermore, for the most part, the research studies focused on this phenomenon are founded on the belief that this condition is common among college students. Therefore, if math anxiety does exist, why is it not being captured in the research studies? The most plausible explanation is inadequacy of math anxiety measures.

Based on researchers’ individual definitions of math anxiety, different instruments measuring it have been created, though none resulted in strong measures of this condition. Though the low level of math anxiety has been commented on by several researchers when using such instruments, the results have still been used to draw conclusions about the construct. As mentioned earlier, the most frequently used measures of math anxiety are MARS based instruments. Although slightly modified and shortened, the remaining items on MARS-based instruments are still mostly identical to the original scale items. The relevance of this forty-year-old items, and their ability to tap into all aspects of math anxiety of college students of 2012, needs to be reevaluated.

As shown in this work, math anxiety (as measured by MARS-Brief) has two major components: numerical anxiety and
math test anxiety. The results of this work (as well as others in the literature) indicate that the dominant factor (of the construct) is math test anxiety, not numerical anxiety. No study to date has incontrovertibly demonstrated that individuals exhibit math anxiety when faced with a mathematical task that is not linked to an assessment of their performance on that task. However, as seen in this work, many of those who could be classified as having math anxiety did not have any indication of numerical anxiety; rather, they had significant levels of math test anxiety. It is hard to accept that an individual should be labeled as math anxious (as measured by MARS, for example) and not have significantly high anxiety when faced with the manipulation of numbers (numerical anxiety). This further confirms that the current definitions and resulting instruments may not be adequate to fully study such a complex construct.

The nature of math anxiety needs to be reassessed. Math anxiety needs to be distinguished from any other similar constructs. For example, one would need to be able to demonstrate that math anxiety is exhibited by some individuals in the absence of math test anxiety. If this is not achievable, then math anxiety needs to be seen as a
part of this encompassing condition, and not an independent phenomenon. If however, it can truly be shown that this condition is not just a side effect of a greater, more dominant construct, then the underlying dimensions need to be clearly defined. Only then can an instrument encompassing all the dimensions of this condition be developed. Until this is achieved, the findings of the studies presented in the literature (as well as in this work), while valid in the specific settings and for the specific definition of math anxiety stated by the researchers, cannot be generalized with a high degree of confidence.

Teaching Practice Implications

Math anxiety is still seen by teachers as one of the major contributors of poor math performance of their students. Understanding the nature of this condition and how it may impact students who supposedly suffer from it, is needed in order to eliminate, or at least minimize its damaging impact.

The methods for diminishing the impacts of math anxiety, or ideally its prevention, need to differ based on gender. The findings of this study suggest that the
structure, and therefore the nature of this condition, vary between male and female students. This implies that teachers need to use different strategies when dealing with different genders. More specifically, a perception of teacher’s attitude toward mathematics plays a significant role in development of math anxiety among female students. Teachers need to express a notably positive attitude toward this discipline in front of their female students.

Teachers, as well as administrators and parents, should encourage continuous enrollment in mathematics courses, as the results of this study indicate that time without mathematics results in development of math anxiety in females. For male students, however, their math preparedness level seems to be the only significant factor in development of this condition. This implies that teachers may want to focus their prevention strategies on improving their male students’ math performance.

Combination of teaching practices that employ prevention strategies (for both males and females) may ensure a diminishing impact of math anxiety, decrease in math avoidance behavior (especially in female students), and improvement in math performance.
Summary of Discussion

Based on the conducted analyses, the posed null hypotheses should be rejected in favor of the research hypotheses. The findings indicated that there were gender differences between correlations of age, math achievement (as measured by math portion of the ACT and math course), perceived parent (mother and father) and teacher attitude towards mathematics and math anxiety. The gender differences were also identified in the nature of the relationships between the proposed predictors and the two major dimensions of math anxiety, Numerical Anxiety and Math Test Anxiety. For female students, outside factors, such as time without mathematics and perceived teacher attitude toward mathematics, seemed to have more prevalent impacts on their anxiety levels. For males, however, inside factors, such as ACT and math course, appeared to be more dominant ones.

Perceived parent attitude toward mathematics did not appear to be a significant predictor of math anxiety, nor any of its major dimensions. Perceived teacher attitude toward mathematics was only related to math anxiety and numerical anxiety levels of female students, while it
played no role in these conditions exhibited by male students. Time without mathematics was a significant predictor of all types of anxieties experienced by females examined in the current study, but it was not identified as a significant indicator for male students. For female students, age, although correlated with time without mathematics, was not related to any of these constructs. Age also did not play a relevant role in male students’ math anxiety or math test anxiety. It was, however, one of only two predictors of numerical anxiety experienced by males. Math preparedness, as measured by the math portion of the ACT, was the only predictor of math anxiety levels of males, and one of two predictors of numerical anxiety and math test anxiety of the same sample. However, ACT did not contribute in the prediction of these phenomena in female students.

While there is literature on the examination of the relationships between the majority of the proposed predictors of math anxiety and math anxiety levels, the same cannot be said for the relationships of these predictors and the major dimensions of math anxiety. This reveals a significant gap in the reported research in the
literature on the nature of these phenomena and the analysis of the dimensions underlying math anxiety.

While the current study recognized two major dimensions of math anxiety that were consistent with the findings in the literature, the results also indicated that the dimension which seemed to be dominating the instrument, did not necessarily dominate the scores on the instrument. Also concerning were relatively low scores on the math anxiety instrument, and especially low scores on the numerical anxiety subscale. Furthermore, significantly higher scores on the math test anxiety subscale raised a question of what exactly these instruments were measuring. While these low scores could be interpreted to suggest that the selected sample was simply not very math anxious, combined with the similar findings reported in the literature, an alternative explanation leads to questioning the validity of the instruments when administered to the current college population.

Future Research

The current study provided more detailed insight into the relationship between the proposed predictors and math
anxiety. It also started an investigation between the same predictors and two major dimensions of math anxiety as measured by MARS-Brief, Numerical Anxiety and Math Anxiety. However, this inquiry revealed areas that warrant further research. These include a development of an instrument measuring math anxiety that will potentially tap into all dimensions of math anxiety experienced by college population of our time. This requires a detailed, in-depth qualitative study designed to identify the major dimensions of this construct, followed by a rigorous quantitative study created to provide psychometric evidence pertaining to validity and reliability of such instrument. Another area that may be further examined is related to student perception of their parents’ and teachers’ attitudes toward mathematics, and relationships between these perceptions and math anxiety, as well as students’ beliefs and attitudes toward this discipline. This research will tie directly to an investigation of math avoidance behavior and students’ decisions to (not) choose mathematics based majors.
REFERENCES


Jackson, C.D. & Leffingwell, R.J. (1999). The role of instructors in creating math anxiety in students from


APPENDICES
APPENDIX A

MATHEMATICS ANXIETY RATING SCALE - BRIEF (MARS-BRIEF)

<table>
<thead>
<tr>
<th>NAME</th>
<th>Total Score</th>
</tr>
</thead>
</table>

MATHEMATICS ANXIETY RATING SCALE: SHORT VERSION

The items in the questionnaire refer to things that may cause fear or apprehension. For each item, place a check in the box under the column that describes how much you are frightened by it nowadays. Work quickly but be sure to consider each item individually.

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>A little</th>
<th>A fair amount</th>
<th>Much</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Taking an examination (final) in a math course.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>2. Thinking about an upcoming math test one week before.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>3. Thinking about an upcoming math test one day before.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>4. Thinking about an upcoming math test one hour before.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>5. Thinking about an upcoming math test five minutes before.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>6. Waiting to get a math test returned in which you expected to do well.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>7. Receiving your final math grade in the mail.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>8. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>9. Being given a “pop” quiz in a math class.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>10. Studying for a math test.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>11. Taking the math section of a college entrance exam.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>12. Taking an examination (quiz) in a math course.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>13. Picking up the math textbook to begin working on a homework assignment.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>14. Being given a homework assignment of many difficult problems which is due the next class meeting.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>15. Getting ready to study for a math test.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

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# Mathematics Anxiety Rating Scale: Short Version

The items in the questionnaire refer to things that may cause fear or apprehension. For each item, place a check in the box under the column that describes how much you are frightened by it nowadays. Work quickly but be sure to consider each item individually.

<table>
<thead>
<tr>
<th></th>
<th>Nor at all</th>
<th>A little</th>
<th>A fair amount</th>
<th>Much</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Taking an examination (final) in a math course.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>2. Thinking about an upcoming math test one week before.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>3. Thinking about an upcoming math test one day before.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>4. Thinking about an upcoming math test one hour before.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>5. Thinking about an upcoming math test five minutes before.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>6. Waiting to get a math test returned in which you expected to do well.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>7. Receiving your final math grade in the mail.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>8. Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9. Being given a &quot;pop&quot; quiz in a math class.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>10. Studying for a math test.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>11. Taking the math section of a college entrance exam.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>12. Taking an examination (quiz) in a math course.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>13. Picking up the math text book to begin working on a homework assignment.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>14. Being given a homework assignment of many difficult problems which is due the next class meeting.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>15. Getting ready to study for a math test.</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE

Demographic Questionnaire

Please mark only one response to all questions:

Student ID Number: ___________________  Student Name: ___________________

1. Gender:
   - [ ] Female
   - [ ] Male

2. When was the last time you completed a math course?
   - [ ] Last semester
   - [ ] Approximately 1 year ago
   - [ ] Approximately 2 years ago
   - [ ] Approximately 3 years ago
   - [ ] Approximately 4 years ago
   - [ ] More than 5, but less than 10 years ago
   - [ ] 10 years ago or longer

3. Your current status:
   - [ ] Post-secondary
   - [ ] Freshman
   - [ ] Sophomore
   - [ ] Junior
   - [ ] Senior
   - [ ] Other

4. Please state your age:

5. Please rate the following statements regarding your teacher(s):

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. She/he liked mathematics.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>2. She/he found mathematics to be easy.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>3. She/he believed that mathematics was important.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>4. She/he enjoyed mathematics.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>5. She/he believed I was good at math.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>6. She/he helped me with my math assignments.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>7. She/he motivated me to work hard at math.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>8. She/he encouraged me to focus on subjects that involved math.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>9. She/he never avoided doing mathematics.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>10. She/he was comfortable performing mathematics tasks.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>11. She/he had a positive attitude toward mathematics.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>12. She/he did not have math anxiety.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>13. She/he was supportive of me pursuing majors involving mathematics.</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
6. Please rate the following statements regarding your mother and father (If you only had interaction with one parent, leave the other part of the question blank):

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>My mother liked mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>1b</td>
<td>My father liked mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2a</td>
<td>My mother found mathematics to be easy.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>2b</td>
<td>My father found mathematics to be easy.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3a</td>
<td>My mother believed that mathematics was important.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>3b</td>
<td>My father believed that mathematics was important.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4a</td>
<td>My mother enjoyed mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>4b</td>
<td>My father enjoyed mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5a</td>
<td>My mother believed I was good at mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>5b</td>
<td>My father believed I was good at mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6a</td>
<td>My mother helped me with my mathematics assignments.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>6b</td>
<td>My father helped me with my mathematics assignments.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7a</td>
<td>My mother motivated me to work hard at mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>7b</td>
<td>My father motivated me to work hard at mathematics.</td>
<td>○</td>
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<td>My mother encouraged me to focus on subjects that involved mathematics.</td>
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<td>My mother avoided doing mathematics.</td>
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<td>10a</td>
<td>My mother was comfortable performing mathematics tasks.</td>
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<td>11a</td>
<td>My mother had a positive attitude toward mathematics.</td>
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<td>My father had a positive attitude toward mathematics.</td>
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<td>12a</td>
<td>My mother did not have mathematics anxiety.</td>
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<td>12b</td>
<td>My father did not have mathematics anxiety.</td>
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<td>13a</td>
<td>My mother was supportive of me pursuing majors involving mathematics.</td>
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<td>13b</td>
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APPENDIX C

CONSENT FORM

Informed Consent Form

Dear Student,

My name is Sandra Wilder, and I am a PhD candidate in the Department of Curricular and Instructional Studies at The University of Akron, Akron, Ohio.

I am conducting a study through the Department of Theoretical and Applied Mathematics and College of Education. The purpose of this study is to investigate whether age, perceived parent and teacher support, math achievement scores, and the length of time passed since completing a math class impact the effects of gender on math anxiety, and if so, how different (if at all) are these impacts for male and female college students.

Although student names, demographic information, and ACT scores will be asked for this investigation, I assure you that confidentiality is protected at every stage of this study. The ACT scores will be obtained, with your permission, from the University’s Institutional Research Office. We will also obtain grades for any previous attempts at your current course in order to eliminate ineligible study participants. Your names/student ID numbers are only used to determine consent given to conduct the study, and to link the collected data with those who consented to having their information used. Nowhere in the presentation of the data will student names be used, linked, or in any way tied to the findings. All records, such as consent forms and surveys, will be kept in a locked filing cabinet during the investigation. Upon completion of the investigation, all documentation linked to you will be destroyed.

There are no anticipated benefits or risks to you. Your participation is entirely voluntary. If at any later date you choose not to have your information used in the data analysis, please let me know, and I will exclude your information from the study. In addition, if you are younger than 18 years of age, your data cannot be used in this study, and therefore you should not participate.

If you have any questions about this research project, please contact me at sandrawilder@uakron.edu.

This research project has been reviewed and approved by The University of Akron Institutional Review Board for the Protection of Human Subjects. Questions about your rights as a research participant can be directed to The Office of Research Services and Sponsored Programs (ORSSP), by calling 330-972-7696.

Thank you.

Sandra

I agree to participate in this research study and to the researcher accessing my math ACT score.

Name (Please Print): ___________________________ Student ID Number: ___________________________

Signature: ___________________________ Date: ___________________________
APPENDIX D
IRB APPROVAL

NOTICE OF APPROVAL

June 28, 2011

Sandra Wicner
659 Mentor Road
Akron, Ohio 44301

From: Sharon McWhorter, IRB Administrator

Re: IRB Number 20119508 "Math Anxiety: Another Gender Issue or is there More to the Story?"

Thank you for submitting your Exemption Request for the referenced study. Your request was approved on June 28, 2011. The protocol represents minimal risk to subjects and matches the following federal category for exemption:

☐ Exemption 1 - Research conducted in established or commonly accepted educational settings, involving normal educational practices.

☐ Exemption 2 - Research involving the use of educational tests, survey procedures, or evaluation of public behavior.

☐ Exemption 3 - Research involving the use of educational tests, survey procedures, or observation of public behavior not exempt under category 2, but subjects are not elected or appointed public officials or candidates for public office.

☐ Exemption 4 - Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens.

☐ Exemption 5 - Research and demonstration projects conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine public programs or benefits.

☐ Exemption 6 - Taste and food quality evaluation and consumer acceptance studies.

Annual continuation applications are not required for exempt projects. If you make changes to the study’s design or procedures that increase the risk to subjects or include activities that do not fall within the approved exemption category, please contact me to discuss whether or not a new application must be submitted. Any such changes or modifications must be reviewed and approved by the IRB prior to implementation.

Please retain this letter for your files. This office will hold your exemption application for a period of three years from the approval date. If you wish to continue this protocol beyond this period, you will need to submit another Exemption Request. If the research is being conducted for a master’s thesis or doctoral dissertation, the student must file a copy of this letter with the thesis or dissertation.

Cc: Lynne Pachnowski - Advisor
Cc: Stephanie Woods - IRB Chair

☑ Approved consent form/s enclosed

Office of Research Services and Sponsored Programs
Akron, OH 44325-2203
330-972-7686 • 330-972-6281 Fax

The University of Akron is an Equal Education and Employment Institution

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Intermediate Algebra

Excursions in Mathematics
Prerequisites: placement test or Basic Math II.
Contemporary applications of mathematics for the non-science major to develop skills in logical thinking and reading technical material. Topics include voting, apportionment, scheduling, patterns, and networks.

College Algebra
Prerequisite: Mathematics Placement Test or completion of 100 with a grade of C- or better. Real numbers, equations and inequalities, linear and quadratic functions. Exponential and logarithmic functions. Systems of equations, matrices, determinants. Permutations and
combinations.

Precalculus Mathematics

Prerequisite: Completion of College Algebra with a grade of C- or better or placement. Functions, polynomial functions, complex numbers, exponential and logarithmic functions, systems of equations, trigonometric functions, mathematical inductions, sequences, and binomial theorem.

Calculus with Business Applications

Prerequisites: Mathematics Placement Test or completion of 145 with a grade of C- or better. Review of functions, derivatives of functions, extrema and concavity, optimization, logarithmic and exponential functions, extrema for multivariate functions. Graphing calculator required. For business majors only.

Analytic Geometry – Calculus I

Prerequisite: Completion of Precalculus with the grade(s) of C- or better. Analytic geometry, limits, continuity, derivatives, tangent and normal lines, extrema of functions, Rolle’s theorem, mean value theorem, related rates, antiderivatives, definite integrals, areas, volumes, arc length.

Analytic Geometry – Calculus II
Prerequisite: Completion of Analytic Geometry - Calculus I with a grade of C- or better. Derivatives of exponential, logarithmic, trigonometric, inverse trigonometric, hyperbolic and inverse hyperbolic functions; methods of integration, sequences, series; moments, centroids, indeterminate forms, polar coordinates.

Interviewee 1 (female, non-math major)

Parent prompt:

My mother was more involved with my homework and education in general than my father was, though even her involvement was limited. I was a strong, self-motivated student from the age of 5 and loved many aspects of school from the first day of kindergarten on. Reading and writing were standout strong points for me very early, whereas math was always a struggle for me. Words made sense in a very natural way; numbers were always alien to me. And it’s not like my parents were math whizzes, neither one of them had a job that required any more of everyday math, and it seemed that they did not expect me to have one.

My mom did encourage me to persist and do the work regardless of whether it was easy or not. But, I was strong-willed and intrinsically lazy. I hated to do things that required diligence or effort. Seeing as I was the last
of five children, I can hardly fault my mother for being less than rigid in regards to my math homework. She helped as much as she could, but the fact of the matter is that the most accepted methods for math application were much different when I was in school than they had been in the forties when mom was in school.

There was, however, one pivotal experience that strongly influenced my attitude about math, and my mother had a lot to do with it. In fourth grade, a handful of us were selected from my class to participate in an experimental math program called OASIS. For a portion of the day twice a week, about six of us were excused from our regular classroom and went with a female teacher to a yellow school bus whose interior had been gutted and refitted as a non-traditional classroom. The floor and walls were covered in low-pile carpeting; there were milk crates full of colorful books and plastic, math-related games and toys. Our chairs were carpet-covered wooden cubes and there were no desks or paper. Rather than slogging through dry-as-the-dessert multiplication tables or long division as we had been doing in our regular classroom, we worked exclusively on these crazy word problems that snuck math in without being overt about it. For example, “here is
a group of six new friends discussing their birthdays. Julie is three years older than Brian; Steven is two years younger than Julie; Marge is one year older than Brian but three years older than Peter; Etc"... and then asking, “how old is John?” or whoever... I never felt I was learning math in this group; we were always just trying to solve a mystery in what felt like a very real-world problem. The program only lasted for one school year. I remember my mom being so happy for me during that school year - and my older brother being insanely jealous that he didn’t get to play the “school bus word games” with us.

Teacher prompt:

Upon returning to college in 2007, after a hiatus of almost twenty years, I decided that one of the first things I would do was to take care of the mathematics requirements for a Bachelor of Arts. Most of my and my husband’s friends already had their BAs in art, language, or literature; and all of them had horror stories about suffering through math classes in their final semesters. I treated my math requirements like spinach and wanted to dutifully consume them before drowning out their bad taste with lovely language and literature classes.
The assessment test placed me in a remedial class, Basic Math II, and I was actually happy about this. I had difficulty balancing my checkbook without a calculator, so I knew full well that I needed to re-learn everything about algebra from the ground up. I had never really understood how the alphabet could betray its dignified language usage by showing up in a math problem anyway. My professor for this class was Mr. X, who also taught part-time at the local high school. The other students in my class groaned when he walked us through his syllabus, which laid out very strict and specific requirements for a three-ring binder with divisions for notes, homework and handouts – which would count as fully 26% of the overall grade, plus several pages of homework due every class meeting and tests almost every week. I was secretly thrilled about these specifications. I am not always a very disciplined person, unless there is someone to whom I am accountable. I knew that with very specific expectations and guidelines I would be able to measure my progress and conquer math once and for all. At the end of the first week, MR. X handed some photocopied sheets to us that he called extra credit exercises. They were math in the form of word puzzles; each math problem’s answer corresponded to a letter, which then
fit into an answer key to solve a riddle. In short, these were genius. I absolutely live for word puzzles, so I did every single one of those math problems. In the process of having fun solving the riddles, I actually got pretty good at algebra.

I finished by acing that class, then went on to ace Statistics for Everyday Life. I was so thrilled to not only have completed my math requirements, but to also have boosted my overall GPA in the process. I made sure to thank Mr. X profusely for all his help and for not compromising his high standards of discipline and organization in one of the most important foundation courses at this university. His class and especially his attitude that math is no big mystery, just a very logical and methodical system of formulas helped me feel far less inferior mathematically. I hope he is still educating and inspiring students of all ages.

Interviewee 2 (female, math major)

Parent prompt:

My parents were very different. My mother was very much a liberal arts person. She moved me to be well read rather than toward the sciences. That is not to say that she blatantly discouraged me, she just preferred the other.
My dad was pretty ambivalent. He didn’t really encourage academics. My dad was very blue collar and was more of a tradesman. He came out of the military and immediately found a career. He put little value in education.

I have three sisters. My older sister being three years older than me and my younger, twin sisters, being seven years younger. My older sister and I were always compared. My parents had two baby girls, the twins, and two older girls, one being academic and one being athletic. I was the latter. If given the situation that I would have to choose to spend time on homework or spend time practicing soccer, cross country, basket ball, etc, my parents would have me go to practice and call the school next day to explain why my school work was not done. They valued me being into sports more than me working on my school work, especially math and sciences. Those disciplines were not viewed as important in our home. Until late in high school, I was under impression that I could succeed exclusively on physical talent.

 Shortly after my junior year, I was given the opportunity to take a serious approach to school, math specifically. I had moved to a completely different state and school. This school was very small and thus did not have all of the
sports that I was used to playing. This really gave me a
lot more time to redirect my attention. I was only doing
cheerleading and cross country as opposed to juggling about
four or five sports a semester. I was taking geometry and
algebra and doing well with minimal effort.

My algebra teacher approached me about joining
mathletes. The idea was not well received at home. I joined
mathletes anyway. I found that I was not smart as I thought
I was. Rather than quitting, I decided that I would try
harder. I was angry that my parents misled me and questions
whether I had actually earner the grades I received. The
following spring, I did not participate in any sports! I
made my focus my education. But unfortunately, it was too
late for math. Majors heavily based on it were out of my
reach. It was impossible to make up everything that I
missed. I started at the University of Wisconsin the next
fall. I had an athletic scholarship and cheered. I was not
at all prepared for college. It was not how well you played
a game after all! I struggled with balancing a social life
and my academics.

I ended up leaving the university. I really believe
that had my parents introduced education, mathematics
specifically, in a more appropriate way, I would have been
far more successful. I chose to go into math because I knew it would be a struggle. I chose to go into education because I don't want math to be struggle for kids like I was. I spend countless hours doing homework and studying. My parents don’t understand why I would choose such a difficult major. My family supports me but does not see that my degree will be fruitful. My position toward my family’s shallow support is to prove them wrong. My stubbornness and dedication, that I probably learned from doing so many sports, will see me through!

Teacher prompt:

The most influence came from the math department at this University. I have had both positive and negative influences. A little encouragement goes a long way with me. I had originally come to this school with the intention of pursuing a BS/MS in math. Not a chance!!! I switched to education although my heart belongs to the math department forever!

I had a pretty terrible semester recently. I had a professor tell me that I would not succeed in math. It was disheartening. I was very angry! I do not take criticism well. This propelled me to work harder as if to succeed would be a slap in the face to the man who tried to prevent
me from reaching my goal. Since that semester, I have had
so much support in my hard work. Teachers and professor
that I have never taken a class from are willing to explain
things and offer help with concepts. One negative comment
has caused me to turn over a new leaf. When I was told that
I would not be able to get past FOAM I knew I had to. Much
like my choice to go into teaching math, I was not going to
quit. It seems that my background in so many sports has
developed a backbone and caused me to have a sense of
dedication. The little jabs from one professor have fueled
my pursuit toward a degree in math field.

I believe there is a problem with math anxiety. I
think it can come from several sources; parents, teachers,
society, and one’s own personality. Overcoming math anxiety
is possible if given the right set of tools and if you are
willing to do a little extra work.

*Interviewee 3 (female, non-math major)*

**Parent prompt:**

I grew up with my dad and he had a very negative view
about math. He looked at it as necessary, but not an
enjoyable thing to do. Actually, even its necessity was
limited to everyday things, such as basic operations, and
maybe, but only maybe percentages. Going through life
without math, or even some sciences for that matter, was perfectly okay for my dad. My dad was always interested in history and politics, so only focused on those subjects as important. And he believed that was how I should view my school assignments. As a result, I was left to do most of my math homework on my own or consult only my teachers for help. Also, I was never very strong with my math skills. I was much better at reading and writing. Instead of pushing me to improve in math, I was encouraged to do enough just to “get by” and focus on my strengths.

I think this impacted my attitude about mathematics in a very negative way. I took geometry, trigonometry, and Precalculus in high school only because it was expected for an honors curriculum. I didn’t enjoy any of the classes and being in them made me feel stupid because I felt I never really grasped the concepts. I also didn’t receive support from my dad to improve my skills or to be comfortable with getting wrong answers. While he knew that I was interested in the social sciences when I went to college, I checked to make sure my major did not have a strong math requirement. I didn’t feel confident or capable of taking any higher level math courses. Even though I was interested in social sciences, I was also interested in the engineering field;
however, because of my lack of confidence in math skills and the negative attitudes I perceived from my father about math, I decided it was best not to pursue a major in the engineering field.

Teacher prompt:

The teacher that had the most influence in my attitude and my beliefs about mathematics was my 10th grade geometry teacher. She was very passionate about math, and geometry in particular. She viewed mathematics as integral part of sciences, and could not imagine anyone disagreeing with her. When I first started the class I was actually excited because she was so energetic and enthusiastic. However, her passion made her very strict and she wasn’t empathic to students who didn’t understand the concepts. I recall one instance where I did very poorly on the homework we had been assigned (we were covering proofs) and she remarked in front of the whole class how poorly I did and then proceeded to have me go up to the chalkboard and write out my proofs so the class could tell me what I did wrong. I was very humiliated when that happened, and after that I had an incredible negative view about my math abilities and mathematics in general.
I think my teacher knew that I was not confident in math, and that my abilities were not as strong as they could be. But even so, I feel she should have given me more support and motivation to overcome that obstacle. I felt that if she had her say, I would never take another math class again, at least not the one she was teaching. I was very reluctant to ask her for help to improve because I felt ridiculed when I did ask questions. In return, I think this was perceived by my geometry teacher as laziness. I was frustrated that my teacher was so passionate about mathematics, yet so unwilling to understand and empathize with students that were not skilled in geometry as she was. I feel that this experience played the most significant role in steering me away from majors that required extensive math courses or higher level math.

*Interviewee 4 (female, math major)*

**Parent prompt:**

My parents had very different views and abilities when it came to mathematics. My mom had zero interest in the topic and found herself very frustrated when attempting to work with numbers. My dad, on the other hand, seems to be a very logistical person as numbers and mathematics come easily to him. He works with and calculates numbers at his
job on a daily basis and I was always amazed at how quickly he could solve a problem. I seem to follow in my mother’s footsteps and find myself easily frustrated with all types of math. I am definitely not a numbers person. And I don’t remember myself ever being one.

My parents were always helpful when it came to school work. Although I was a very independent child, rarely asking for help on homework or school projects, both mom and dad were always there offering a helping hand. But neither one of them expected me to excel in math or do anything more in that subject that I was required. I would have to say that I probably asked for the most help when it came to math homework and dad was usually the go to guy. I don’t feel that my parents influence had any impact on my attitudes or beliefs toward mathematics. I had to work hard to succeed in that subject and formed a negative opinion of math all on my own. It wasn’t until studying for my undergraduate degree that I formed a somewhat positive opinion of mathematics. My parents definitely knew how I felt about math and would have never suggested a major or career with that as the basis. They were supportive in my education and encouraged me to push through my hard times with math.
Teacher prompt:

I feel that my math teachers had more of an influence on my attitudes and beliefs toward mathematics than my parents. I cannot say that I had an outstanding math teacher throughout my education and because of this I formed a positive or negative opinion. I guess none of them impacted me that strongly, in either direction. As a future educator, I have learned to differentiate instruction and teach to the many different learning abilities of children. Knowing this now, I realize that my past math educators were not teaching to my style of learning. But I also realize that I was not the only student in their classroom, and they couldn’t cater to my needs only. I can’t help but think just how the other kids in my classes felt. Math just never clicked for me, but yet I pursued major that requires a strong body of math knowledge. I feel that teachers could potentially have a lot of influence on their students, but they have to choose to do so.

My math teachers did not affect my career choice in positive way. I wish I had had a teacher that could have changed my view on math. Sure, many of them were very excited about doing and teaching mathematics, and
emphasized its importance, but they failed to relay it to me. I don’t recall a single teacher who encouraged me to pursue anything even remotely connected with math. It is frustrating that to this day I get nervous and flustered when dealing with numbers. At times I feel it is too late to do anything about it, but I realized I will have to change it soon. Although my major is not math based, it does involve mathematics, and not feeling comfortable doing it may be detrimental to my career. I hope to work on this in the future and feel that as I learn to teach math to young children, I will also be teaching myself.  

**Interviewee 5 (female, non-math)**

**Parent prompt:**

Growing up my parents helped me learn how to count, and do simple addition and subtraction. As I got older and began getting into multiplication and division my parents were a great help in the learning process. My parents believe that math is a big part of life and will be used no matter what type of job you will be doing. Since this was the belief, they would always help me to develop my math skills.

My father especially would be a big help; he would write down a long division problem for me and have me solve
it. They really wanted me to push myself and succeed in what I do and math was a big part of that. If I had homework they would try to help me as much as they can. As I went to high school the math got a lot harder. Both my parents didn’t go to college so therefore have not dealt with difficult mathematics for a very long time, so it was hard for them to help me in high school. If they were not able to help me they sent me to my brother. He was the math whizz. And he further supported me learning mathematics and understanding its importance.

Since my parents had such strong views on mathematics and education in general, I actually enjoyed math in school, it came easy for the most part. When I went to college I only had to take two math classes and they were not a challenge, actually they were too easy. The reason I only had to take two was because I was an art major. As much as people say math is not needed for art they were wrong. I actually use math all the time and I am very grateful I listened to my parents and learned it the proper way.

**Teacher prompt:**

Being a Graphic Designer my teachers have always made jokes about how we are all terrible at math and that’s why...
we are graphic designers. They never really mentioned their views on math or beliefs. But this was not true in the earlier years, especially in middle school. My 7th grade math teacher believed that at that point everyone should know what their plans were for the future, and if those plans didn’t involve mathematics, he saw no reason to be bothered with those students. I already knew, at least the area I was getting into after high school, and if it wasn’t for the strong math support I had at home, I would probably be as clueless in mathematics as many of my classmates who fell under the similar influences.

In college, although my math teachers minimize the role of math in the art world, I feel this subject is very important. For projects we need to know the exact size of what we are making and sometimes we have to do math to figure that out. Since my teachers always make comments about arts majors being “math-free”, I always make that joke now too, and so do my friends. Most art majors I know are terrible at math. However, regardless of that and the fact they often make fun of math, they are always there to help me figure out the specs for a project and help me figure of the size of anything else that will be on the project, such as pictures. When working with photos there
is a lot of math involved, you need to figure out the resolution and the size of the photo. If the photo is not the right size you need to adjust both resolution and size, and there is a formula to do that.

I am glad that in my major I don’t have to do a lot of math, and that is one of the reasons I chose it. I was good at math, but not great and I couldn’t see myself doing a major that required extensive amounts of math. But no matter what, math will always be a part of my life. Thanks mom and dad!

Interview 6 (female, math-based major)

Parent prompt:

My parents’ attitude was consistent and focused on doing well in all of my course and not just mathematics. They necessitated and required good grades, but did not push me into doing “better” in one field or the next. My parents’ behavior exemplified what they taught their children. They always worked hard at their careers, and gave 110%. It was by their example that I learned that working hard for something pays off, not only financially, but in your overall sense of worth in society.

My parents supported whatever I was interested in, but kept a watchful on all of my grades, not necessarily just
in math. They always said that I could A’s as long as I was focused, completed all the homework, and studied diligently for exams. Everything else would follow. They did not force me into any subject or career they deemed was the thing to be in. as long as I remained on the honor roll, they did not mind what area I chose to pursue. It was more my own feel for the subject, and I was the one that made the choice whether to like math as a subject or not. I chose Finance as my initial major and career, and thus I know I am aware that I chose a major that will require me to work with numbers on a daily basis. I really enjoy math, and my parents’ drive for success allowed me to excel in any area I chose.

**Teacher prompt:**

I did not have the fortunate experience of having an influential mathematics teacher. Most math teachers I had followed the curriculum without including "real life" examples or making it contemporary for young adults. Although they taught the correct material, and I understood it, I felt as if many of my classmates struggled often. I'm not sure what it is about math that has people so confused and anxious, especially when taking a test. I am a tutor now, and many of the students' questions arise from
their inability to do simple math or think broadly about the solution.

My professors could see that I was excelling in math, stayed quiet, and did not ask many questions. My ability was proven when asked to be a tutor. My teachers did not influence my attitudes towards math, one way or the other. It was always due to internal motivation that drove me to do well. They also did not affect my career choice. I wish they would have explained different math careers, while still in high school. I didn't know what math oriented careers there were until I was already in college a few years.

Interview 7 (male, non-math based major)

Parent prompt:

My parents had a great attitude towards math and believed in its use and importance. This was reflected in their ability to do mental math very quickly. They always tried to teach me how to do math quickly in my head and stressed its importance. This however did not stick. So while I had my parents’ supports, I feel I simply did not have the ability or their interest in this subject. Unfortunately this resulted in me being math deficient. Once I started lacking in my math assignments and tests, my
parents stop reinforcing it. They realized I would never be able to get math the way they do, and I wasn’t willing to put in a great amount of work in this subject that interested me very little at the time. This unfortunately affected my career choice because anything related to math was out of the question for me. In hindsight, I wish I did work harder on it. At least I wouldn’t have shut the doors to many lucrative majors that are definitely out of the reach for me.

Teacher prompt:

The teacher who had the most influence on me was my high school algebra teacher. She was very unorganized and generally a bad teacher. Her attitudes and beliefs towards math was like any other math teacher, she saw the importance and value of it. But she failed to show us that importance. She made math seem so difficult and got very impatient with students if they didn’t understand the material. She always stressed how important learning algebra, but again, she never showed us any real life examples and try to relate it to our lives. It is possible that because I didn’t like her I also came to detest algebra. My lack of success in this class is a direct factor in my major choice because I choose a major I knew
would have very little math in it. That was, in my opinion, my only chance to excel in my major and career.

*Interview 8 (male, math based)*

**Parent prompt:**

My father has always had a very deep respect for mathematics and analytical thinking. He made sure he influences my attitude toward mathematics while I was growing up. He was successful and he and his beliefs definitely shaped my view on the subject. He would often present me problems that he had to solve at work and showed me more advanced math even when I was in elementary school. It was great to know that there were so many layers of this subject and that if I only worked hard I would be able to know them all.

His behavior has always reflected a concern for order and structure, something akin to much of mathematics. I would say he cultivated a great respect for this type of thinking. Most of my positive feelings towards the subject also resulted from my own experiences in math, and the enjoyment that came from solving problems and thinking in ways that others could not. I do believe that my father did have a significant influence on my major and career choice, Applied Mathematics, because he expressed the importance of
doing what it is that I enjoyed and outlining my strong skills in math as something I should pursue.

Teacher prompt:

My high school physics professor had a very pragmatic view on mathematics in that he believed it was a tool, but just like any tool that there was a proper use and an improper use for it. This attitude made the building of a mathematical argument for physical phenomenon more efficient because math was only used where it was necessary. I have adopted this mentality as my own because I find it very functional, especially in my particular field where sometimes making a simple observation can save myself half a page of work.

My professor had a strong belief in my abilities in mathematics, most especially he outlined my deep understanding of calculus more specifically integral calculus. His belief in me, coming from a man who had worked in industry as a design team manager, gave me great confidence as I moved on to a four-year university. This confidence ultimately led me to pursue a career in mathematics and has helped me stay the course through difficult classes and material.

Interview 9 (male, non-math based)
Parent prompt:

My parents play a very significant role in the development of my attitudes toward mathematics. Both my parents were very strongly oriented toward social sciences, well, mostly politics. So math was not much used or emphasized in our house. The reason for that could also be the fact that neither one of my parents seemed to be very good at this subject. Hence, when the time of math homework came, needless to say, there were not very helpful.

Being an only child, there was no one else that could be assisting me with my math assignment. And as I was already finding that subject difficult, not having my parents point out that it is important, gave me a great excuse to completely neglect this subject and focus on things that interested me. And in my case those were languages. My lack of studying of mathematics did not bring any negative consequences from my parents. They understood, and at the time I was grateful that they didn’t force me to study harder.

Only when I started college classes did I realize just how handicapped I was when it came to selecting my major. Although languages were my passion, I was well aware that jobs would not be lining up for someone who has a degree in
Spanish or French. Engineering seemed interesting, but after talking to my advisor I realized I could never get through those classes. I struggled in the basic classes that were required. In hindsight, I wish my parents were not so flexible when it came to math. Even if they did not care for it, they should’ve known how important it is and definitely connected to many other majors and careers.

**Teacher prompt:**

My teachers were no help either. As I always struggled in math, my teachers believed it was easier to just ignore me than to try and help. I never did ask for help. I did my homework as best as I could, and managed to get solid passing grade throughout high school, mostly on the account of being an overall good student.

All my teachers were typical math teachers, except the one in my 9th grade algebra class. To this day I still believe that he was not really a math teacher, but just someone who was bumped into that position. I couldn’t really judge his knowledge of the material, for I wasn’t really sure how to do any of this, but my teacher always seemed confused, and his lecture tone always had that question mark at the end. He lacked self-confidence, and he
himself didn’t seem to enjoy the subject. Needless to say, no one in the class learned anything that year.

*Interview 10 (male, math based)*

**Parent prompt:**

Being raised in a foreign country, Lebanon, had great advantages in terms of getting a successful education. In Lebanon, the focus on education was extremely important and essential. Most of the population speaks three languages and it is necessary to perfect all science courses, and mathematics as well. My father graduated with masters in civil engineering, and his scores in the math section were outstanding. He was top of his class, especially in the mathematics area. After all mathematics is not memorization, it is being able to think logically. It is more like common sense, when you grasp the idea or the concept, you will hopefully be able to apply them to different set of problems after doing some practice.

Following such an attitude in approaching a subject was very interesting and challenging to me and looking at how my father was able to use the same logic in real life situations, I was eager to do the same, as I saw the sequence of logic he followed which led to a great and successful life of his, leaving most of it for his
children, his mind and logical thinking would positively affect his succeeding generations. I was not very much interested in leading engineering or mathematics major. I was more interested in going into the biology/pre-medical field. Nonetheless I am always able to use that common sense and that sequence of logic that my dad uses and be able to apply it to the different situations of life.

Mathematics is indeed one of the subjects we have to take in school, but it is very unique and essential as we can relate the same logic we use to approach a math problem to the logic and common sense we use in every day’s life. The question is how to solve the problem, what are the steps we have to take in order to get to the correct answer, what is the sequence of logic we have to follow in order to solve the problem, what concept should we apply for this specific problem?? And that Is where people face the most difficulties.

Teacher prompt:

This specific teacher had a great passion towards mathematics and was able to relate lots of real life situations to mathematics. He felt that teaching was his mission and especially when teaching the subject he loved the most. Observing his passion towards math and the way he
was teaching, not just made it easy on me to grasp the information but to love learning more about mathematics and have the same passion to solve the different problems that were given. However, he did not affect in the choice of my career.

Interview 11 (male, non-math based)

Parent prompt:

My parent had a negative attitude towards mathematics. These attitudes were reflected every time I came home and needed help with math homework. I would be told that they didn’t know how to do it and that I would just have to ask the teacher. My parents would say that they didn’t have anyone to help them with their math homework when they were in school and that is why we had teachers.

These negative experiences with my parent impacted my beliefs and choices greatly. Not only was I not encouraged, I knew I would have to fend for myself if I wanted to do anything that had to do with math. What I lack the most from my parents is their belief that I could really learn and master mathematics, and maybe one day major in something related to it. Their attitude was very clear when it came to that. They didn’t expect me to be capable of learning, what in their eyes was a very difficult subject.
matter. Math was something that neither of my parents valued much, but then unfortunately they didn’t value the importance of education either.

Teacher prompt:

My teacher believed that everyone could learn mathematics. All it was required was a strong support, good teaching, and a lot of hard work. This was reflected every day in the classroom. She would always relate mathematics to other more concrete things in my life that I could relate to. Finally I was able to see concrete applications of this subject and that helped a great deal. This impacted my belief system greatly because she actually ended up convincing me that I could do something and be good at something if I looked at it a different way.

Interview 12 (male, math based)

My father has been the parent who has had the most influence on my attitudes and beliefs toward mathematics. My father believes that avoiding math is virtually impossible, thus it should be a subject that I take seriously. My father has always been confident in my ability toward math because I began to excel at the subject from a very young age. In fact, math was my strongest subject from elementary school through high school. Over
the course of my life, my father has persistently encouraged me to succeed not only in math, but in every class that I’ve ever attempted. Whenever I needed help he tried his hardest to help (especially when it came to math), and at times he would spend several hours helping me work through difficult math problems and concepts (e.g., writing proofs for geometry). I’d have to say that my father’s attitudes and beliefs toward mathematics really didn’t have a huge effect on my major or career choice. On the other hand, I do believe that my father (as well as my mother) has disciplined me to be the determined and committed student that I am today.

Teacher prompt:

I would have to say that there really wasn’t a teacher in elementary, junior high, or high school that has had a significantly large influence on my attitudes and beliefs toward mathematics. However, I fortunately had the opportunity to take an Advanced Statistics course this past semester here at The University of Akron, and the professor teaching this course was phenomenal. She made learning a variety of advanced statistical analyses (e.g., multiple regression, ANOVA’s and factor analysis) very enjoyable and applicable to “real life” situations. Moreover, this
professor was very enthusiastic about teaching her course, and had the ability to make abstract concepts sort of “come to life”. This professor has had a decent influence on my attitudes and beliefs toward statistics. In fact, I am now seriously considering a PhD program in assessment, measurement and evaluation later down the road.
APPENDIX G

ACT AND SAT CONVERSION CHART

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(Dorans, 1999)