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A Study of Pre-Service Teachers: Is it Really Mathematics Anxiety?

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A STUDY OF PRESERVICE TEACHERS: IS IT REALLY MATHEMATICS ANXIETY?

A Dissertation Presented

by

MARSHA MARIE GUILLORY BRYANT

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF EDUCATION

MAY 2009

Child and Family Studies

A STUDY OF PRESERVICE TEACHERS: IS IT REALLY MATHEMATICS ANXIETY?

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by

MARSHA MARIE GUILLORY BRYANT

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Ernest D. Washington, Chair

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Portia C. Elliott, Member

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Nathaniel Whitaker, Member

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Christine B. McCormick, Dean
School of Education

DEDICATION

For my parents
Joseph Alfie Ray Guillory
September 11, 1943 to January 31, 1992

For leaving the world a better place and for not completing your own dissertation, this
one I share with you.

and

Priscilla Ann Guillory

For carrying the torch.

And

For my husband
Timothy Jermaine Bryant

A beautiful mind.

And

For my son
Miles Timothy Bryant

You are a blessing.

ACKNOWLEDGMENTS

parents and my sister, for your endless love and invaluable, immeasurable and boundless support, my heartfelt gratitude. Your dedication and devotion sustain me. To my maternal grandparents, Wilson and Ellen Guillory, my paternal grandparents, Ashton and Viola Guillory, aunts, uncles and many cousins, thank you for a lifetime of love and support. To my friends, friends are family that we chose for ourselves. Thank you.

To my best friend, life partner, soul mate and loving husband Timothy Bryant and our son Miles Timothy Bryant you nourish my heart and soul. Tim has been a loving and supportive companion on this journey, and sometimes, metaphorically speaking "carried me" when I needed it most. Thank you Tim, for the laughter, your endless love, your dedication and your commitment to our dreams. Miles, you have been on this journey with me your entire life. Thank you for your unconditional love. You truly inspire me. To Tim and Miles, it is a wonderful life.

A radio personality on WEIB in Northampton, Massachusetts, J. D. Houston, signs off the air each morning stating and I quote "If you want something in your life that you've never had, you're going to have to do something that you've never done". Thank you for this thoughtful quote and smooth jazz listening.

Timothy, Miles, Mother, Laurice, other family and friends, I wholeheartedly thank you for making my life more fulfilled and pleasant for being in it. I am truly blessed and most fortunate to have all of you in my life.

ABSTRACT

A STUDY OF PRESERVICE TEACHERS: IS IT REALLY MATHEMATICS ANXIETY?

MAY 2009

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This research study was motivated by a hypothesis, generated on the basis of formal and informal observations, personal and professional experiences, discussions with prospective teachers and a pilot study conducted by this author; that pre-service teachers have a high level of mathematics anxiety and negative attitudes about mathematics. The primary purpose of this research was to examine the relationship between mathematics anxiety and pre-service teachers. The secondary purposes of this study were to examine the relationship between anxiety and performance and to examine the relationship between math anxiety, test anxiety, and stereotype threat.

A quantitative experimental research design was used to investigate the research questions. The population consisted of prospective teachers at colleges and universities in Louisiana. The sets of data are mathematics anxiety of prospective teachers, a test anxiety inventory and a mathematics performance task. A personal data questionnaire was used to gather demographic information and attitudinal information about the participants.

The implications of this study for elementary teacher education programs point to increased attention on the mathematics anxiety of pre-service teachers. This process is two-fold. One, it is recommended that pre-service teachers be made aware of their mathematics anxiety level and their attitudes about mathematics and two, it is recommended that teacher education programs acknowledge and address the importance of these affective variables and their role in pedagogy.

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INTRODUCTION

The National Council of Teachers of Mathematics (NCTM) asserts that all

students are capable of learning mathematics and that all students must learn

mathematics. This is in stark contrast to the historical position and traditional approaches

to mathematics education. Tate (1995) found that mathematics education has been closely

associated with a Eurocentric philosophy of elitism and social stratification that aimed to

build and sustain economic power and hegemony. Similarly, Atweh et al. (1998) found

that "The function of school mathematics in Western culture as a badge of eligibility for

the privileges of society has often been noted" (p. 63). Given the position posited by

NCTM and the role of mathematics in society, all students should be encouraged to learn

and value mathematics.

However, the overall level of knowledge in mathematics possessed by our

nation's children and adults is described as minimal at best (Clark-Meeks et al., 1982;

Karp, 1991; McDevitt et al., 1993; Battista, 1999).

> "The effectiveness of mathematics instruction is being examined on various levels
> due to the growing concern that the nation's children, as well as adults, lack
> competence in the subject. Educational researchers prodded by this concern have
> investigated various factors thought to be related to success in mathematics with
> groups that include students in the elementary, junior high and high schools;
> parents of these students; prospective and present teachers. One of the factors
> receiving much attention is mathematics anxiety and one of the groups which is
> steadily being investigated is prospective teachers" (Clark-Meeks et al., 1982).

Some factors contributing to the failure of students to learn mathematics that have

received much attention in the literature are teaching methods, teachers' lack of

knowledge, attitudes of classroom teachers toward mathematics and teacher "math

anxiety." Although each of the factors discussed is important, this study will focus primarily on "math anxiety."

A primary obstacle in investigating the research on mathematics anxiety is to formulate a definition of anxiety. It is important to understand that anxiety is a multifaceted construct involving behavioral, psychological, affective, physiological and cognitive functions. Levitt (1980) suggests that definitions of anxiety are full of abstract constructs that often require defining. For example, early research on anxiety in the 1930s failed to distinguish between anxiety and fear. Historically, the focus was not to define anxiety, but to ask which came first—fear or anxiety. There has been little agreement among researchers as to which came first, therefore the debate continues as to which is the stimulus and which is the response.

Anxiety and fear are different mechanisms. One solution suggests that the difference between fear and anxiety is that fear is a reaction to a specific danger while anxiety is unspecific, "vague," "objectless" (May, 1977, p. 205). "Thus anxiety is the basic, underlying reaction-the generic term; and fear is the expression of the same capacity in its specific, objective form" (May, 1977, p. 224). The underlying assumption is that anxiety is most commonly used in an empirical sense to describe a complex reaction or response (Spielberger, 1966). For example, Eysenck (1992) defines anxiety as an unpleasant emotion and aversive state and the primary function of anxiety is to facilitate and detect threats in our environments.

The phenomenon known as mathematics anxiety or mathophobia is prevalent in the literature. Lazarus (1974) characterized "mathophobes" as individuals who have mathematics anxiety (i.e. low confidence and negative attitudes about mathematics).

This area of study is of great interest to educators. The literature includes aspects of mathematics anxiety ranging from describing the phenomenon, to math avoidance, to the transfer of mathematics anxiety from teacher to student; and finally to immediate and long-term educational implications.

During the last three decades, much of the research has focused on students at our nation's colleges and universities. This research suggests that many students entering post-secondary institutions are ill prepared for mathematics courses at the university level and experience mathematics anxiety. Furthermore, the literature suggests that mathematics anxiety is extremely common among today's college and university students (Lazarus, 1974; Malinsky et al., 2006) and is a factor limiting educational and career choices of university students, particularly women (Sells, 1972; Betz, 1978; Tobias, 1981; Hembree, 1990; Chipman et al, 1992; Ashcraft, 2002).

For example, a research report on mathematics anxiety and science careers among college females, found a strong association between math attitudes and careers in the sciences (Chipman et al, 1992). Specifically, Sells' (1972) provides evidence that students who avoid mathematics courses limit their educational and career opportunities. She surveyed the top 12% of the students entering the University of California at Berkeley. Of the top 12%, 43% of the entering males and 92% of the entering females had only one high school algebra course. Given the pre-calculus trigonometry requirement for many of the university majors, this alarming statistic for female students essentially eliminated over 70% of the majors offered at the university. In fact, they were left with only five fields: music, social work, humanities, guidance and counseling; and elementary education in which women were present in large numbers. Moreover,

almost thirty years after Sells' study at the University of California, Berkeley; the United

States Department of Labor Bureau of Labor Statistics and the United States Census

Bureau (2000) presented findings of employment by gender and occupation. The data

reported that 83.8% of teachers in elementary schools are female. The percentage of

males employed as elementary school teachers was only 16.2%. In 2003, The National

Educators Association (NEA) and the National Center for Education Statistics reported

that males accounted for only 9% of teachers in elementary school and females

represented 91% of elementary school teachers.

My experiences working with pre-service teachers provided me with many

opportunities to engage in discussions and observations. Time and time again, pre-service

teachers expressed their anxieties and attitudes about mathematics. Specifically, pre-

service teachers reported high levels of anxiety and negative attitudes about mathematics.

My experiences, both formal and informal, mirror the findings of the literature. This

study will focus on education majors as the literature identifies this group as one that

experiences high levels of mathematics anxiety.

The question then becomes what variables are associated with or contribute to a

high level of mathematics anxiety in pre-service teachers and therefore, warrant further

investigation. There are many factors that may contribute to math anxiety, however two

confounding variables seen as most relevant to an understanding of the phenomenon are

test anxiety and stereotype threat.

An integral part of the research on mathematics anxiety is test anxiety;

specifically, the relationship between math anxiety and test anxiety. While some

researchers question the distinction between the two anxieties (Woods, 1988; Kazelskis et

al., 2000), other researchers suggest that the two anxieties are related, but are not equivalent constructs (Dew et al., 1983; Dew et al., 1984; Zettle & Raines, 2000).

Test anxiety is an important variable influencing academic performance. Zeidner (1998) defines test anxiety as a construct, which includes physiological and behavioral responses, which accompany concern about possible negative consequences or failure on an examination or similar evaluative situations. Test anxiety and its impact on performance are well documented in the literature. Specifically, the literature suggests that test anxiety impairs performance (Mandler & Sarason, 1952; Liebert & Morris, 1967).

Another construct that has been an integral part of the research on mathematics anxiety and performance is stereotype threat. Steele (1999) defines stereotype threat as "The threat of being viewed through the lens of a negative stereotype or the fear of doing something that would inadvertently confirm the stereotype" (p. 46). Stereotype threat impacts test performance and one's abilities to do well in certain subjects. The research literature has focused on stereotypes about the math ability of females and the impact of stereotype knowledge on performance (Spencer et al., 1999, Aronson, 1999, Brown and Josephs, 1999) and minorities in all academic areas including testing situations (Steele & Aronson, 1995; Steele, 1997; Aronson et al., 1998). The current research suggests that stereotype threat negatively impacts women's performance in mathematics domains (Spencer et al., 1999; Schmader, 2001).

Figure 1: A Cycle of Pre-Service Teacher Anxiety

Stereotype
Threat

Test Threat

Pre-Service
Teachers

Performance
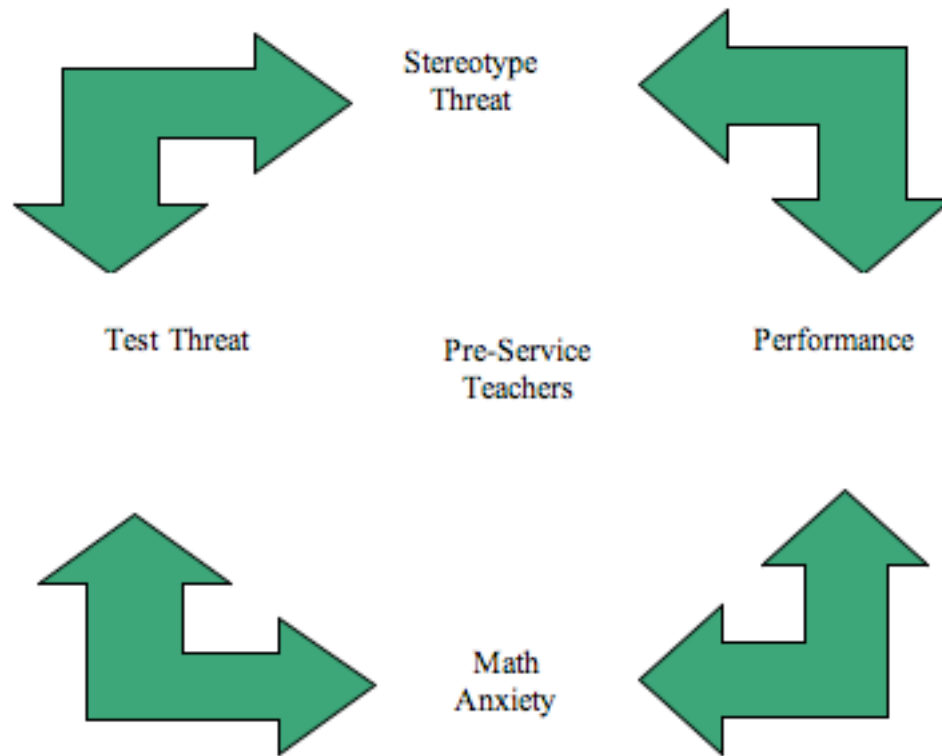
Math
Anxiety

Therefore, a study that examines the influence of stereotype threat and test anxiety (i.e. test threat) on performance would help to answer questions and increase the body of literature about mathematics anxiety in pre-service teachers—the overwhelming majority of whom are women. The results of this study could benefit individuals, programs and institutions interested in mathematics anxiety in pre-service teachers and teacher education.

Definition of Terms

The following definitions apply to terms used in this research study:

1) <u>Mathematics</u>- Mathematics is defined as "The study of numbers and their form, arrangement, and associated relationships, using rigorously defined literal, numerical, and operational symbols (Webster's II New College Dictionary, 2001, p.675)". Devlin (2000) defines mathematics as a science of patterns and the relationships between patterns. For the purpose of this paper, mathematics is defined as the science of numbers and patterns and the relationships between the two.

2) <u>Attitudes</u>- Along with modern academic psychology, Ruffell et al. (1998) define attitude as a multi-dimensional construct. That is, attitude is composed of cognitive and affective domains. The cognitive domain is an expression of beliefs (a conviction that something is true) about an object and affective domain is an expression of feelings toward an object. With regards to attitudes and mathematics, Aiken (1972, p. 229) defines attitude as "approximately the same as enjoyment, interest, and to some extent level of anxiety". For the purposes of this paper, attitude is defined as a predisposition (positive or negative) to respond in a consistent manner toward an object, idea, concept or situation.

3) <u>Anxiety</u>- Anxiety, a multifaceted phenomenon. Anxiety is primarily discussed in two forms: state anxiety and trait anxiety. State anxiety is temporary while trait anxiety is long standing. Eysenck (1992) defines anxiety as an unpleasant and aversive state. Furthermore, he suggests that the primary function of anxiety is to

facilitate and detect threats in our environments. For the purposes of this study, anxiety will be discussed in the form of state anxiety.

4) <u>State Anxiety</u>- State anxiety (s-anxiety) is defined as an unpleasant emotion experienced in the midst of apprehension, nervousness and worry specifically as it relates to an evaluative situation (Spielberger & Vagg, 1985).

5) <u>Trait Anxiety</u>- Spielberger and Vagg (1995) define trait anxiety (t-anxiety) as stable individual differences in the tendency to respond with state anxiety in threatening situations.

6) <u>Math Anxiety</u>- Math anxiety is defined as a type of state anxiety. According to Richardson and Suinn (1972, p. 551) "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". Tobias (1981) characterizes math anxious individuals as those who mistrust their problem solving abilities and experiences a high level of stress when called upon to use those abilities, particularly in public. Furthermore, these persons apologize for their lack of skills and avoid activities associated with mathematics. Math anxiety is an attitude combining many factors to affect math performance and an uneasiness, nervousness or apprehension regarding mathematics (Chavez and Widmer, 1982).

7) <u>Test Anxiety</u>- Zeidner (1998) defines test anxiety as a construct, which includes physiological and behavioral responses, which accompany concern about possible negative consequences or failure on an examination or similar evaluative situations. Similarly, Spielberger (1995) defined test anxiety as "The stress

associated with examination situations (stressor), the subjective interpretation of a

test as more or less threatening for a particular person (threat), and the emotional

states that are evoked in test situations" (p. 6). The stressor and threat result in an

anxiety reaction. Spielberger (1995) offers the following

$$\text{Stressor} \rightarrow \text{Threat} \rightarrow \text{State Anxiety.}$$

8) Stereotype Threat- Steele (1999) offers the following definition of stereotype

threat. "The threat of being viewed through the lens of a negative stereotype or

the fear of doing something that would inadvertently confirm the stereotype" (p.

46).

9) Pre-service teacher- For the purposes of this paper, a pre-service teacher is a

student enrolled in a university teacher education program.

10) Performance Task- For the purposes of this paper, the performance task consists

of five math questions presented in multiple-choice format

Statement of the Problem

The majority of elementary education students come to their education courses at

the university level having only experienced traditional methods of mathematics

instruction. As a result of their classroom experiences, the majority of elementary

education students come to their education courses with deeply rooted anxieties and

attitudes about mathematics.

A significant body of research suggests that pre-service teachers experience

higher levels of mathematics anxiety than other university students (e.g., Sells, 1972;

Lazarus, 1974; Sovchik et al., 1981; Kelly & Tomhave, 1985; Battista, 1986; Burton,

1986; Wood, 1988; Harper & Daane, 1998; Trujillo & Hadfield, 1999; Haylock, 2001;

Vinson, 2001; Bursal & Paznokas, 2006; and Swars et al., 2006) and represent a "significant minority" (Woods, 1998).

A significant body of literature also exists suggesting that high levels of mathematics anxiety experienced by teachers may be perpetuated in their classrooms. That is, it leads to the transmission of anxiety; and a fear of mathematics to their students (Lazarus, 1974; Tobias, 1981; Bulmahn & Young, 1982; Larson, 1983; Kelly & Tomhave, 1985; Martinez, 1987; Karp, 1989; Hembree, 1990; Vinson, 2001; Sloan et al., 2002; and Furner & Berman, 2005).

As a result of the anxiety levels, some researchers question future teacher's potential teaching effectiveness in the mathematics classroom (Sovchik et al., 1981; Teague & Austin-Martin, 1981; Larson, 1983; Bush, 1989; Hembree, 1990). "Although it is only a conjecture, we believe that students surrounded by confident teachers who are excited and positive about their role in the students' learning process will exhibit fewer symptoms of math anxiety than students whose teachers are themselves anxious, uncomfortable, and negative about teaching mathematics" (Kelly & Tomhave, 1985, p. 53).

The literature establishes that pre-service teachers have a higher level of math anxiety than other university students and questions the teaching effectiveness of future teachers. Given the findings in the literature and the conjecture posited by Kelly and Tomhave (1985), it is clear is that the cycle of mathematics anxiety must be broken. Based on the review of the literature and my experiences, two things must be done in an attempt to break the cycle of mathematics anxiety:

1) Teacher education programs must provide pre-service teachers with decontextualized mathematics instructional experiences. That is, teacher education programs must provide opportunities for pre-service teachers to experience mathematics "being taught in the way they should teach" Lindquist and Elliott (1996).

2) Teacher education programs need to explicitly address math anxiety and feelings about math.

Therefore, this dissertation concentrates on two specific areas of research as it relates to mathematics anxiety in pre-service teachers. The first is the relationship between math anxiety, test anxiety, and stereotype threat. Finally, this dissertation focuses on and how math anxiety, test anxiety, and stereotype threat affect performance (i.e. math test).

Rationale

The level of mathematics knowledge of our nation's children and adults are widely studied and criticized by the media, academic research and educational institutions from primary schools to universities. Various viewpoints have been shared regarding our poor mathematical knowledge and the sources of our poor mathematical knowledge. The literature identifies mathematics anxiety, negative mathematics attitudes and traditional teaching methods as the primary sources of our poor mathematical knowledge. It is important to note that teachers do not bear sole responsibility for the poor performance on mathematics in our society; however teachers are a catalyst for change and improvement (Brush, 1981; Charlesworth, 1997; and Trujillo & Hadfield, 1999). Therefore, this study will examine the relationship between mathematics anxiety,

test anxiety and stereotype threat in pre-service teachers, and the influence of the three variables on math performance.

Math anxiety has been regarded as a form of test anxiety. Therefore, this study will compare the effects of math anxiety, test anxiety, and stereotype threat upon math performance in pre-service teachers. However, following a study on test anxiety and math anxiety with university students, Zettle and Raines (2000) suggest that despite the relationship between math and test anxiety a distinction between the two should be maintained.

> "While math anxiety commonly has been regarded as a subtype or form of test anxiety, there appear to be both conceptual and empirical reasons for not viewing the two as equivalent. Richardson and Woolfolk (1980), for example, have argued that math anxiety is most meaningfully conceptualized as a reaction to both mathematical content per se (numbers) and to evaluative situations, such as testing, in which mathematical skills are assessed. In particular, as it relates to mathematical content, math anxiety may be associated with feelings of perfectionism and inferiority and concerns about gender roles and identity. Empirically, math anxiety measures have been found to be more closely related to each other than to test anxiety and its components, especially among women college students (Dew, Galassi, & Galassi, 1983)" (Zettle and Raines, 2000, p. 247).

Test anxiety is a behavioral and physiological reaction to test or test-like situations. Since test anxiety and math anxiety may be allied, this study will measure self-reported math anxiety and self-reported test anxiety; and examine the relationship between the two anxieties and performance.

Trujillo & Hadfield (1999) define mathematics anxiety as a state of discomfort that occurs as a response to situations which involve mathematical tasks and that are perceived as a threat. Therefore threat, specifically stereotype threat is one variable being examined in this research study. Steele (1999) defines stereotype threat as "The threat of being viewed through the lens of a negative stereotype or the fear of doing something that

would inadvertently confirm the stereotype" (p. 46). The research on stereotype threat suggests that social stigmas can influence performance and school outcomes particularly as it relates to mathematics (Spencer et al., 1999, Aronson, 1999, Brown and Josephs, 1999).

The literature suggests individuals who are members of negatively stereotyped groups will be conscious of the stereotype, and this may negatively affect their performance. In the context of math performance, the phenomenon of stereotype threat has been demonstrated in females. The gender stereotype associated with math ability may cause females to experience anxiety related to the confirmation of the stereotype, and as a result, their performance on the math test will suffer. Since stereotype threat may influence anxiety, examining the relationship between the two variables may provide additional insight on math anxiety in pre-service teachers.

Because teachers are catalysts for change, it is imperative that teacher education programs have information about math anxiety. Moreover, it is imperative that teacher education programs acknowledge and address math anxiety in pre-service teachers. A review of the literature revealed much about math anxiety and pre-service teachers. However, the researcher found no record of a study designed to specifically to examine math anxiety, test anxiety, stereotype threat and performance in pre-service teachers and whether significant differences exists between the experimental conditions (i.e. math anxiety, test anxiety, and stereotype threat).

Significance of the Study

As educators prepare students to function in a technological world, it is important to note that classroom teachers are the primary change agents. As such, it is important

that education students leave their pre-service training with the necessary mathematics content and pedagogical strategies. However, equally important are the attitudes of pre-service teachers. The attitudes of teachers toward mathematics influences instructional methods in the classroom and instructional methods have the potential to create mathematic anxiety in students (Tobias, 1978, 1980; Teague & Austin-Martin, 1981; Cornell, 1999; Malinsky et al., 2006). Therefore, it is imperative that teacher educators and others who work with pre-service teachers be informed of mathematics anxiety and its impact on instruction in the classroom.

The significance of this study is two-fold. First, it will deconstruct the confounding variables that contribute to the culture of anxiety in pre-service teachers. The variables identified for this study are mathematics anxiety, test anxiety and stereotype threat. Secondly, this study deploys an experimental design to determine if there are significant differences between math anxiety, test anxiety and stereotype threat. Secondarily, this study examines the differences between males and female pre-service teachers on two different measures of anxiety.

Purpose of the Study

The purposes of this research are to clarify the relationship between math anxiety test anxiety, stereotype threat, and performance. Specifically, the impact mathematics anxiety, test anxiety, stereotype threat on math performance will be examined in this investigation.

This research study was motivated by a hypothesis-generated on the basis of formal and informal observations, discussions with prospective teachers and a pilot study

conducted by this author. This investigation led to the formation of the following

research questions:

1) Is there a relationship between anxiety and performance?

    a. Is there a relationship between mathematics anxiety and performance in pre-service teachers?

    b. Is there a relationship between test anxiety and performance in pre-service teachers?

2) Is there a significant difference in the influences of math anxiety, test anxiety, and stereotype threat upon math performance in pre-service teachers?

Hypotheses

The data collected will be analyzed to accept or reject the following hypotheses:

Ho: There is no relationship between mathematics anxiety and performance in pre-service teachers.

Ho: There is no relationship between mathematics anxiety and gender in pre-service teachers.

Ho: There is no relationship between test anxiety and performance in pre-service teachers.

Ho: There is no relationship between test anxiety and gender toward mathematics in pre-service teachers.

Ho: There is no relationship between stereotype threat and performance in pre-service teachers.

Ho: There is no relationship between stereotype threat and gender toward mathematics in pre-service teachers.

Ho: There is no relationship between mathematics anxiety, test anxiety, stereotype threat and performance in pre-service teachers.

CHAPTER 2

REVIEW OF RESEARCH AND LITERATURE

In an extensive literature review on mathematics anxiety and elementary teachers,

Wood (1988) concluded:

> "It is a matter of judgment as to whether the level of mathematics anxiety in the population of elementary school teachers of mathematics is higher or lower than in the population at large; however, in some sense this is not the issue. If the scores of the MARS on some other scale are approximately the same for elementary teachers as for the general public, but these levels indicate an overall fear of or distaste for mathematics, then there is still a problem. Elementary teachers are charged with an extremely important role to engender an excitement for learning in all subject areas, including mathematics. Such a perspective implies that elementary teachers have an attitude toward mathematics that is better than the attitudes of the public at large and they should feel more comfortable teaching mathematics than members of the general population. Despite the fact that the research does not support the hypothesis that most elementary hate or fear mathematics, it does support the contention that a significant minority feel this way " (p.11).

Moreover, in quoting Mihalko (1978, p.36) Wood wrote, it is true and logical that

elementar y school teachers "Cannot be expected to generate enthusiasm and excitement

for a subject for which they have fear or anxiety. If the cycle of mathophobia is to be

broken, it must be broken in the teacher education institution" (p.11).

There is an agreement among professional educators and non-educators alike that

many students are not receiving adequate mathematics instruction (Lazarus, 1974;

McDevitt et al, 1993; Battista, 1999) and that many students in the United States have a

moderate level of procedural knowledge of mathematics and an even lower level of

conceptual knowledge (Vinson et al, 1998). In this increasingly technological and

economically competitive world, those without adequate mathematical skills (i.e.

conceptual knowledge and procedural knowledge) limit their future opportunities (Sells,

1978; Tobias, 1980; Greenwood, 1984; Williams, 1988; Zettle & Raines, 2000; Furner & Berman, 2005; Dowker, 2005). Therefore, it is imperative that students receive meaningful and effective mathematics instruction beginning at the elementary school level.

Teachers, especially pre-service teachers, because of their future impact in our classrooms, have a responsibility not only to make use of teaching approaches that engage and excite students, but they also have a responsibility to embrace and promote a positive culture towards mathematics, the teaching of mathematics and the learning of mathematics. Given that pre-service teachers are the future leaders in our nation's classroom, they are the focus of this research study.

Research suggests that mathematics anxiety is extremely common among today's college and university students (Lazarus, 1974; Malinsky et al, 2006; Iossi, 2007). Lazarus (1974) Moreover, within the university population, the incidence of mathematics anxiety is significantly larger among elementary education students (Burton, 1979; Sovchik et al, 1981; Kelly & Tomhave, 1985; Battista, 1986; Wood, 1988; Cook & Briggs, 1991; Harper & Daane, 1998; Haylock, 2001; Bursal & Paznokas, 2006; Swars et al 2006) and elementary education students have poorer attitudes towards mathematics (Bulmahn & Young, 1982; Larson, 1983; Emenker, 1996).

Although there are many aspects of mathematics anxiety that are important, this review of the literature provides a synthesis of the published literature on mathematics anxiety as it relates to pre-service teachers. Consequently, the literature on test anxiety, stereotype threat and mathematics performance; and its relationship to mathematics anxiety will also be examined in this review of the literature. As illustrated below, this

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research study lies at the center of the topics discussed in the literature review. The

topics reviewed are represented pictorial below in Figure 2.

Figure 2: Literature Review Topics
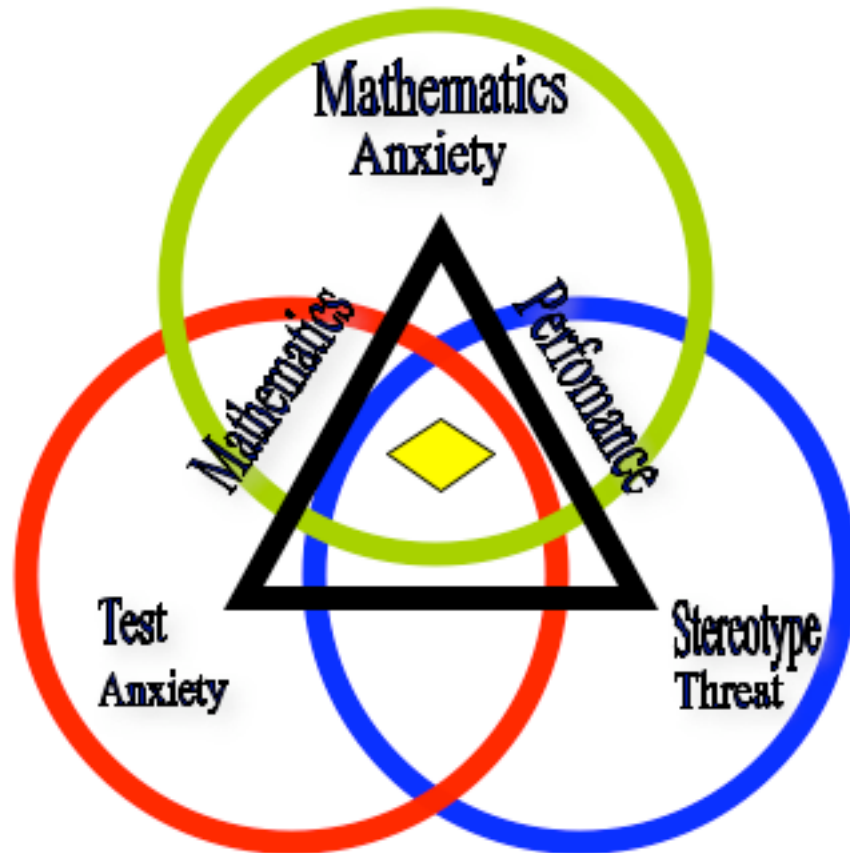
<u>**Anxiety**</u>

It is important to understand that anxiety is a construct. That is, "a broad

abstraction, a hypothetical entity with no actual physical existence but that has proven

useful in explaining observable phenomenon" (Levitt, 1980: p. 4). According to Levitt,

constructs are popular yet non-scientific "things" used to explain behaviors and are well

suited for accounting for a non-unitary phenomenon such as anxiety. Eysenck (1992)

suggests that the primary function of anxiety is to facilitate and detect threats in our

environments. In sum, anxiety, a multifaceted construct, which involves behavioral, psychological, physiological or cognitive functions.

The discussion of anxiety, how it is defined and how it is most commonly used brings us to the discussion on mathematics anxiety. What is mathematics anxiety? Research suggests that mathematics anxiety is more than a dislike of mathematics but reflects an internal aversion to mathematics related activities that interfere with performance (Tobias, 1980; Kelly & Tomhave, 1985; Hembree, 1990; Burns, 1998; Zettle & Raines, 2002; Bursal & Paznokas, 2006).

Psychologists and educators have submitted numerous definitions for mathematics anxiety. Several definitions will be examined. An early definition of mathematics anxiety was formulated by Richardson and Suinn (1972, p. 551), "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. Similarly, Chavez and Widmer (1982) define math anxiety as an uneasiness, nervousness or apprehension regarding mathematics and mathematical performance. Richardson and Woofolk (1980) suggest that math anxiety is a reaction to mathematical content as well as a reaction to evaluative situations.

Tobias (1981) defined mathematics anxiety by providing characteristics of mathematical anxious individuals. She characterized math anxious individuals as those who mistrust their problem solving abilities and experiences a high level of stress when called upon to use those abilities, particularly in public. These persons apologize for their lack of skills and avoid activities associated with mathematics. Mathematics anxiety was defined by Trujillo & Hadfield (1999) as a state of discomfort that occurs as a response to

situations which involve mathematical tasks and that are perceived as a threat. Elliott (1983) posited that mathematics anxiety results for nonalignment of cortial and subcortial parts of the brain noting the physiological dimension.

The literature suggests a relationship between mathematics anxiety and attitude toward mathematics. Bessant (1995) stated that attitudes toward mathematics appear to be intertwined with the effects of mathematics anxiety. Bursal & Paznokas (2006) showed that mathematics anxiety often manifests itself as a lack of understanding- often leading to avoidance of the subject- thus creating a negative attitude toward (Zettle and Raines, 2002). The definitions discussed account for mathematics anxiety as a multidimensional construct with cognitive and psychological roots (Harper & Daane, 1998; Bursal & Paznokas, 2006). This multidimensional construct manifests itself in individual attitudes thereby affecting individual performance.

Mathematics Anxiety and Avoidance

It is reasonable to assume that students who exhibit levels of mathematics anxiety will also avoid tasks involving mathematics. "Avoiders use past histories of failures to predict future failures. They become so adamant with their 'I can'ts' and their 'I couldn't' that, just as self-prophesied, they don't. They don't do well in mathematics and they ultimately do not continue it" (Elliott, 1983, p. 783). The consequence of avoiding mathematics has serious implications (Sells, 1972; Tobias, 1980; Hembree, 1990). For example, Hembree (1990) suggests that when students avoid the study of mathematics, it erodes the country's resources base in science and technology. It is thought that the avoidance of mathematics especially applies to females. Finally, a question to be

considered is could avoidance be attributed to other factors like stereotype threat (Steele, 1997; Spencer et al, 1999; Osborne, 2001) or volitional impoverishment (Elliott, 1986).

What is volition? According to Zhu (2004), "Volitions, as acts of will, are special mental events of activities by which an agent consciously and actively exercises her agency to voluntarily direct her thoughts and action" (p. 302). Kuhls and Kazen-Saad (1989) offer a definition of volition which argues that it is an active mechanism that supports the maintenance of information related to current intention and resolves conflicts between motivational and cognitive preference hierarchies. Heikkero (2008) delineated five aspects of the volition dimension: ethos, attitude, pathos, will (intention) and emotion. These five aspects as outlined by Hiekkero (2008) combined with the definitions presented earlier appear to infer that volition has some semblance of a psychological reality in the mind. Moreover, the definitions suggest that volition may have an active role in learning, particularly learning often avoided topics like mathematics.

Valle et al (2003) discussed the volitional dimension and learning. The authors suggest that volitional dimension (i.e. persistence and effort- the will component) affect learning and academic achievement. "Results achieved will significantly affect causality attributions, which, in turn, will lead students to make various judgments and evaluations of personal control and self-efficacy regarding task requirement. These judgments and evaluations will have reciprocal influence and will also affect metacognitive, cognitive, and affective systems, as well as future perceptions and expectancies in similar tasks" (Valle et al, 2003, p. 563).

For example, Sells' (1972) provides evidence that students who avoid mathematics courses limit their career opportunities. In this study, the researcher surveyed the top 12% of the students entering the University of California at Berkeley. Of the top 12%, 43% of the entering males and 92% of the entering females had only one high school algebra course. Given the pre-calculus trigonometry requirement for many of the university majors, this alarming statistic for female students essentially eliminated over 70% of the majors offered at the university. In fact, they were left with only five fields: music, social work, humanities, guidance and counseling; and elementary education. The trend continues, Mantey (2007) reported that females dominate college majors in areas of health, psychology, and education while males make up the majority of engineering, physical science, and mathematics majors.

Eighteen years after Sells' study at the University of California, Berkeley, the United States Department of Labor Bureau of Labor Statistics (1990) presented findings of employment by gender and occupation. The data reported that over 85% of teachers in our elementary schools are female. The percentage of males employed as elementary school teachers was only 14.8%.

Hembree (1990) used a meta-analysis to integrate the findings of 151 studies to examine mathematics anxiety. The results suggest a relationship between mathematics anxiety and avoidance of the subject. The findings are similar to those of Sells (1972) and Kelly and Tomhave (1985). Specifically, Hembree found that "positive attitudes towards mathematics consistently related to low mathematics anxiety" (p. 38). Following his analysis, Hembree suggests that mathematics anxiety threatens both achievement and participation in mathematics.

Additional research suggests that high anxious students took fewer high school mathematics courses and showed less intention (i.e. intentionality is a dimension of volitional competencies) in high school and college to take more mathematics courses. Of those high anxious students, female students reported higher levels of mathematics anxiety across all grades. Kelly and Tomhave (1985) also provide empirical evidence of a link between anxiety and avoidance. The results document mathematics avoidance, the researchers found enrollment in the lower level mathematics courses (algebra, mathematics concepts, introduction to statistic), were 48% female. However, for the mathematics courses required for admittance into professional programs, the percentage of female enrollment was 30%. This study indicates that the women at this college are avoiding mathematics courses necessary for many of the technological and professional careers.

In sum, the literature suggests that math avoidance can be attributed to many factors including math anxiety (Kelly & Tomhave, 1985 and Hembree, 1990) and volition (Elliott, 1983, 1986). These factors appear to have direct implications for students of mathematics. According to Elliott (1986) limiting opportunities is akin to volition. Specifically, opportunities are limited when individuals are unable or unwilling to fantasize goal attainment via mathematics that contributes to avoidant behavior. Finally, Heikkero (2008) posited that "Human actions always spring from our desires and emotions and our willingness and motivation to act" (p. 161).

Mathematics Anxiety and Transmission

"Math anxiety usually arises from a lack of confidence when working in mathematical situations. Many people incorrectly assume that math anxiety and an inability to be successful in mathematics are inherited from one's parents. Several legitimate factors contribute to, and increase the severity of, this

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perception. For instance, gender and ethnic backgrounds are not determining factors in mathematical competence, but peers' and teachers' attitudes toward gender and ethnicity may increase or decrease one's confidence in mathematics skills. The methods use to teach mathematics skills may affect whether a student feels successful and develops mathematical self-confidence. Finally, family and peer attitudes may positively or negatively influence students' attitudes towards mathematics, which in turn affect their levels of confidence" (Stuart, 2000, p. 331).

A body of research suggests that high levels of anxiety lead to the transmission of anxiety; and a fear of mathematics in their students (Lazarus, 1974; Tobias, 1981; Bulmahn & Young, 1982; Larson, 1983; Kelly & Tomhave, 1985; Martinez, 1987; Karp, 1989; Hembree, 1990; Vinson, 2001; Sloan et al, 2002; and Furner & Berman, 2005). As a result of their anxiety, some researchers question their potential teaching effectiveness in the mathematics classroom (Sovchik et al, 1981;Teague & Austin-Martin, 1981; Larson, 1983; Bush, 1989; Hembree, 1990).

The literature suggests that the causes of mathematics anxiety can be categorized into two related areas: environmental and pedagogical. The research also suggests that these variables are inextricably linked. Trujillo and Hadfield (1999) suggests that environmental, intellectual, personality and pedagogical factors cause a lack of confidence in mathematical ability. For example, the lack of perceived usefulness of mathematics in everyday life and mathematics presented as a rigid set of rules are examples of environmental factors. Intellectual factors include lack of confidence in mathematical ability and attitude. Examples of personality factors include reluctance to ask a question, low self-esteem and viewing mathematics as a male domain. Finally, exposure to poor mathematics instruction in the classroom and mismatched learning styles are examples of pedagogical factors.

The elementary school experiences of pre-service teachers are often transferred to their practice as future teachers. Lazarus (1974) stated "Far more important than the teacher's advanced knowledge are his own attitudes and feelings about mathematics, because these will surely be imparted to the students whether the teacher intends it or not" (p. 22). Moreover, Lazarus suggested that teachers should encourage probing questions and exploration in the mathematics classroom.

Bulmahn & Young (1982) posited that the elementary school teacher is a "significant part of any individual's early mathematical environment" (p.55). In addition, the researchers suggest that elementary school teachers transfer mathematics anxiety to students. However, data was not presented by Bulmahn & Young to support their position.

Kelly & Tomhave (1985) hypothesized that a significant proportion of prospective teachers were mathematical anxious individuals, and elementary school teachers, the majority of whom are females, may be perpetuating mathematics anxiety in their classrooms. They concluded that "Although it is only a conjecture, we believe that students who are surrounded by confident teachers who are excited and positive about their role in the students' learning process will exhibit fewer symptoms of math anxiety than students whose teachers are themselves anxious, uncomfortable, and negative about teaching mathematics" (p. 53).

In a study of mathematics anxiety as it related to changes in student mathematics achievement, anxiety; and selected teaching practices, Bush (1989) found no significant difference in changes in mathematics anxiety between students of mathematical anxious teachers and non-mathematical anxious teachers. Moreover, Bush offers the following

"The contention that mathematics anxiety is transmitted from teachers to students (Lazarus, 1974; Bulmahn and Young, 1982; Kelly and Tomhave) was not supported by the results of this study. There was no significant relationship between teacher mathematics anxiety and changes in student mathematics anxiety" (p.509).

In addition, the results of the study yielded few significant relationships between mathematics anxiety and teaching practices. Mathematical anxious teachers did not appear to teach drastically different than non-mathematical anxious teachers. Similarly, Chavez and Widmer (1982) studied the mathematics anxiety of elementary school teachers. They found that most teachers who themselves had unpleasant experiences with mathematics were determined to make mathematics a pleasant and enjoyable experience for their students. A final conclusion of the Bush study indicated a slight tendency for mathematically anxious teachers to be more traditional in their teaching.

In summary, the studies reviewed suggest that student math achievement may be linked to the teachers' level of anxiety and attitude. Moreover, anxiety and attitude may have a direct impact on the teaching methods teachers' use, much of which is decontextualized, which goes against the recommendations posited by NCTM and others. The influence of teacher anxiety should be considered if student achievement is to improve in mathematics education.

Mathematics Anxiety and Pre-Service Teachers

A significant body of research exists which suggests that pre-service teachers experience higher levels of mathematics anxiety than others (Sells, 1972; Lazarus, 1974; Sovchik et al, 1981; Kelly & Tomhave, 1985; Battista, 1986; Burton, 1986; Wood, 1988; Harper & Daane, 1998; Trujillo & Hadfield, 1999; Haylock, 2001; Vinson, 2001; Bursal

& Paznokas, 2006; and Swars et al 2006) and represent a "significant minority" (Woods, 1998). The research studies reviewed below discuss and compare pre-service teachers to other university students.

Elementary school teachers may be perpetuating mathematics anxiety in their own classrooms. Kelly and Tomhave (1985) suggest that if their findings are representative, pre-service teachers and elementary school teachers transmit their own anxiety about mathematics to the students in their classroom. They conducted a study of university students at various academic levels and experiences. The groups included freshmen who had no college preparatory math classes in high school, freshmen enrolled in a college algebra course thus minimal college math preparation, seniors who had no college math courses, students enrolled in a workshop for math anxiety and forty-three elementary education majors (of which only six had taken courses beyond college algebra).

The Mathematics Anxiety Rating Scale (MARS) was administered to the participants. The findings suggests that on average, elementary education majors both male and female scored higher on the MARS than any other group with the exception of the mathematics anxious workshop group. Male education majors scored lower than any other group, female education majors scored higher on the MARS than any other group except the mathematics anxious group, and finally both male and female elementary education students scored higher on the MARS than any other group with the exception of the mathematics anxious workshop group. In addition, the data suggests that a high percentage of female elementary education students have mathematics anxiety.

Becker (1986) investigated the attitudes of perspective teachers and compared them to other university students. She disagreed with the findings of Kelly and Tomhave,

but specifically addressed the findings by Bulmahn and Young (1982) suggesting that little or no data has been published documenting poor attitudes and anxieties and that Bulmahn and Young presented no such data in their article.

Due to her questions and concerns, Becker conducted a study using the Fennema-Sherman Mathematics Attitudes Scales (1976) with students enrolled in an astronomy course and the pre-service teachers enrolled in a mathematics course. The results of this study suggest that the elementary education students scored lower on the anxiety scale (i.e. were more anxious) than any other attitude scale. For example, the mean score on anxiety for elementary education students was statistically different from a neutral score. In addition, elementary education students scored significantly lower than the students enrolled in the general astronomy course. Specifically, the mean score for elementary education students was lower than astronomy students (i.e. elementary education students (M= 2.81) and astronomy students was M= 3.22). Following her analysis of the data, Becker concluded that:

> "Although definitions of "high anxious" can vary; it seems inappropriate to classify this sample of perspective elementary teachers as having an alarming degree of mathematics anxiety. Also, education student as a whole were rather positive in their attitudes toward success in mathematics and the usefulness of mathematics (both these scores were higher than those of the astronomy sample), and they did not stereotype mathematic as a male domain. Therefore, I would not classify the education students as having very negative attitudes towards mathematics; they have attitudes similar to those of a more general sample of students" (p. 51).

Becker also compared her data with the data originally collected by Fennema and Sherman (1976, 1981). The elementary education students were somewhat more anxious than a broad selection of high school students in the Fennema and Sherman study. However, the scores on the attitudes scales for both groups were similar. Finally, Becker

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concluded, "Although these pre-service teachers' attitudes were not very positive, neither were they as negative as implied by Bulmahn and Young. Certainly it would be preferable for all teachers to be very positive about mathematics. But we may be expecting too much if we want education students to be more positive about mathematics than college students in general" (p.51).

Similarities between the Becker study and the Bulmahn & Young study include the use of the same instrument to measure the anxiety of university students, the use of elementary education students enrolled in a required mathematics course and the use of other university students. Differences between the two studies are the number of students and the courses in which the non-elementary education majors were enrolled at the time of participation in the studies. Becker surveyed 81 elementary education students enrolled in a required mathematics course and 71 students enrolled in a general astronomy course. Bulmahn and Young surveyed over 200 university students, approximately half were female elementary education students enrolled in a required mathematics course and the other half consisted of students across various majors who were enrolled in a finite mathematics course or a psychology course. Both genders were included in the study; however it is important to note that nearly 90% of the elementary education students were females while the gender division of students in the finite mathematics course and psychology course was "about even" (p. 55).

The literature suggests that students enrolled in advanced mathematics courses, particularly at the university level, tend to be less anxious about mathematics (Sells, 1972; Lazarus, 1974). If students have elected to take advanced mathematics courses it stands to reason that they like or feel more comfortable in mathematics related activities

so anxieties would not be high. Therefore, the findings of the Bulmahn and Young study may be attributed to the fact that some of the subjects were enrolled in an advanced college mathematics course specifically, finite mathematics.

The studies reviewed comparing university students majoring in education and university students with other majors concluded that elementary education students experience high levels of math anxiety. Moreover, the studies suggests that not only do pre-service teachers experience high levels of math anxiety, but pre-service teachers experiences are more math anxious than other university students

Math Anxiety and Mathematics Methods Courses

"Through exploration of their own backgrounds, pre-service teachers may identify and confront their own personal levels of mathematics anxiety prior to entering the classroom as teachers" (Trujillo and Hadfield, 1999, p. 2). Research suggests that taking a mathematics methods course could lessen mathematics anxiety in prospective elementary teachers and improve the quality of classroom instruction (Sovchik et al, 1981; Battista, 1986; Hembree, 1990; Emenaker, 1996; Harper and Daane, 1998; Tooke and Lindstrom, 1998; Trujillo and Hadfield, 1999; Bursal and Paznokas, 2006; Vinson, 2001; and Gresham, 2007). The literature indicates that mathematics methods courses reduce math anxiety and positively impacts the attitudes of pre-service teachers. A mathematics methods course impacts teaching approaches likely to be used in the elementary school classroom.

For example, Bulmahn and Young (1982) conducted a study in which they hypothesized that "In general, the kind of person who is drawn to elementary school teaching is not necessarily the kind who enjoys mathematics in the broad sense-from its

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logical beauty to its real-world applications" (p.55). On the basis of a questionnaire and attitude essays, they found that most elementary education studies identified mathematics as their worst subject. Another, more troubling, finding of the study was that many beginning elementary education students felt little or no need for a higher level of mathematical skills beyond basic computation.

> "Most alarming was the feeling expressed by many beginning education students that elementary teachers do not really have to be very good at mathematics beyond the basic computation. They seem to have the notion that with the teacher's manual in hand, they have all the mathematics they need to know" (Bulmahn and Young, 1986, p.56)

Similarly, Sovchik et al, (1981) conducted a quantitative study to determine if a mathematics methods course lessens the mathematics anxiety of the pre-service teachers enrolled in the course. Throughout the course, the instructors applied teaching approaches they termed "active learning approaches". The students enrolled in the course completed the Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn (1972) to determine their level of mathematics anxiety. The results of the study showed that anxiety scores of the pre-service teachers were lower at the end of the course than at the beginning of the course.

Battista (1986) also examined the hypothesis that a mathematics methods course can reduce mathematics anxiety in pre-service teachers. The mathematics methods course included a field experience, lecture and discussion sessions and small group activities. Battista's finding are similar to those of Sovchik et al (1981), the mathematics methods course did reduce the anxiety of pre-service teachers. Specifically, "The results indicated that for pre-service teachers who entered the methods course with above

average mathematics anxiety generally showed a noteworthy decline in anxiety during the course.

Battista hypothesized two possible reasons for the decline in mathematics anxiety in the pre-service teachers in the study. One, an awareness of the usefulness of mathematics (volition increases) gained in the methods course particularly the field experience reduced mathematics anxiety. Two, as a result of the methods course and the field experience, the pre-service teachers now have a raised level of confidence.

Harper and Daane (1998) conducted a study to measure the mathematics anxiety of pre-service teachers before and after a mathematics methods course. The purpose of the study was to identify the causes of mathematics anxiety in pre-service teachers and to determine the impact of a mathematics methods course on their anxiety. The fifty-three pre-service teachers completed the Mathematics Anxiety Rating Scale (MARS) at the beginning of the semester and then again at the end of the semester. In addition to the scales, interviews were conducted with eleven of the students enrolled in the mathematics methods course, all students completed a Factors Influencing Mathematics Anxiety (FIMA- a twenty-six item checklist related to experiences in mathematics or the mathematics classroom) prior to the start of the course, and a Methods Course Reflection (MCR); a seven item checklist given at the end of the course to determine the influences on mathematics anxiety.

Harper and Daane discussed their findings as: (1) mathematics anxiety still persists in many prospective classroom teachers, (2) the cause of the anxiety can often be traced to elementary school and rigid; traditional classroom instruction, and (3) the mathematics methods course can have a significant impact on future teachers learning to

cope with their own anxiety and learning to teach mathematics in ways that limit anxiety in students.

Tooke and Lindstrom (1998) conducted a quantitative study to look at the possibility of reducing mathematics anxiety in pre-service elementary teachers. The study investigated pre-service teachers enrolled in either Mathematics for Elementary Teachers and Mathematics Methods. Two sections of each course were offered. The researchers investigated three cases: (1) one section of the mathematics for elementary teachers was taught in a very traditional manner; (2) another section of mathematics for elementary teachers was taught in the spirit of the recommendations of NCTM; and (3) the third case included two sections of the mathematics methods course that addressed the same mathematical content of the mathematics for elementary teachers but it also addressed appropriate pedagogy. In the third case, lectures were phrased "this is how you should teach this" and more emphasis was placed on the phrase "this is how kids will learn this" (Tooke and Lindstrom, 1998, p. 137).

The same mathematics content was presented in all four courses and all students in the study completed the Mathematics Anxiety Rating Scale for Adults. (MARS-A). The pre-test results indicated similar levels of anxiety were present in all sections (i.e. the two sections of the Mathematics for Teachers and the two sections of the Mathematics Methods). The post-test results on the MARS-A yielded no significant difference at the conclusion of the semester between the students enrolled in the traditional mathematics for elementary teachers section and the nontraditional mathematics for elementary teachers section. However, students enrolled in the two mathematics methods courses did register a significant reduction in their mathematics anxiety. Tooke and Lindstrom

suggests that the differences noted in the students enrolled in the mathematics methods course is likely attributed to the presentation of the material in the mathematics methods courses.

Trujillo and Hadfield (1999) conducted a qualitative and quantitative study to investigate mathematics anxiety among pre-service teachers. Fifty students enrolled in a mathematics methods course were administered the Revised Mathematics Anxiety Rating Scale (R-MARS) (Plake and Parker, 1982). Five of the six students with the highest level of mathematics anxiety participated in in-depth interviews to explore their experiences as it relates to mathematics anxiety. One common theme identified was negative early school experiences. The five pre-service teachers recalled their experiences in mathematics, and one student shared in an interview, "There was a lot of drill and repetition and no hands on. There were so many rules and a lot of memorization. I was not confident in math and I was afraid to get the wrong answer. There was so much pressure and only one right way. I felt isolated and alone when I didn't understand" (p.4).

The university mathematics methods course exposed all of the pre-service teachers to more non-traditional methods of teaching mathematics. A participant's description of the course was representative of the whole group, "It was hands-on. I learned different techniques. It was the first time I realized how math could be taught. We used manipulatives, games, blocks, and geometrical shapes. We worked in groups, and for word problems we learned how to picture it and write things down" (p. 6).

Following participation in the study and the mathematics methods course, the participants indicated that they intended to use progressive and non-traditional approaches to teaching mathematics in the elementary classroom. Even though the

purposes of this study was not to study mathematics anxiety among five specific pre-service teachers, it was encouraging that each of the participants was aware of his/her negative attitudes toward mathematics and each was determined to prevent the transmission of those negative attitudes and mathematics anxiety to students. Trujillo and Hadfield concluded that effective mathematics methods courses tend to reduce mathematics anxiety. Moreover, effective mathematics methods course improve not only methodology, but mathematics content and conceptual knowledge as well.

Vinson (2001) conducted a study to investigate the changes in levels of mathematics anxiety among pre-service teachers in two different mathematics methods courses; one course emphasized the use of manipulative while the other course did not emphasize the use of manipulatives. It should be noted that the same professor taught the both courses. The purposes of the study were to emphasize the concrete learning of mathematics by the use of manipulatives during a methods course to aid pre-service teachers in a better understanding of the concepts and procedures in mathematics; and to provide pre-service teachers with pedagogical strategies for the mathematics classroom.

The students enrolled in the courses for four consecutive quarters in one academic year. Each student participant completed the Mathematics Anxiety Rating Scale (MARS) the first week of the course and then again in the last week. The primary researcher (the course professor) also used of informal observations, informal discussions and informal interviews.

The fall quarter scores yielded no significant difference, therefore following the fall quarter, the primary researcher introduced and utilized more manipulatives in the consecutive quarters. Following the changes, the students in the winter, spring and

summer quarters had significant lower levels of anxiety than those students enrolled in the initial quarter of the study.

Through interviews, the researcher found that pre-service teachers shared a common thread following the mathematics methods course, "They were better able to understand mathematics concepts and procedures when they were presented on the pictorial and concrete levels" (p. 93). As a result of this study, Vinson discusses two conclusions. One, if pre-service teachers were able to understand the material, then they can teach the material. Secondly, Vinson concluded that a mathematics methods course that emphasized the use of manipulatives has a positive impact on future teachers, "What they are able to teach effectively will reduce the anxiety levels of their future students" (p.93).

Bursal and Paznokas (2006) conducted a single observation study to measure the mathematics anxiety levels and confidence levels of sixty-five pre-service teachers to teach elementary mathematics and science. They hypothesized that one's level of confidence was negatively related to one's level of anxiety.

The subjects were enrolled in three methods courses one for teaching elementary mathematics, one for teaching elementary science and one for teaching elementary social studies. The courses were not designed as experimental treatments therefore no manipulation was involved in the current study. All of the pre-service teachers in the three courses completed the Revised-Mathematics Anxiety Survey (R-MANX), the Science Teaching Efficacy Belief Instrument (STEBI-B; Rigs and Enochs, 1990) and the Math Teaching Efficacy Belief Instrument (MTEBI; Enochs, Smith & Huinker, 2000) at the end of the semester. The R-MANX was administered first in order to determine the

math anxiety level of each student. After the R-MANX has been completed, each student completed the MTEBI and the STEBI-B to assess their attitudes and beliefs regarding mathematics and science instruction in elementary classrooms.

Based on the MARS score, students were placed into one of three groups: high anxiety, moderate anxiety and low anxiety. The data analysis included Pearson correlation coefficients and an ANOVA to explain relationships and compare the mean MTEBI and STEBI scores of the different anxiety groups. The data suggests that a negative relationship exist between mathematics anxiety and confidence, the higher the pre-service teacher's level of mathematics anxiety, the lower the confidence. Specifically, this study found that over half of the pre-service teachers in the high mathematics anxiety group believe that they can not effectively teach mathematics and nearly half believe that they do not know the procedures to effectively teach mathematics concepts.

Bursal and Paznokas also concluded that attitudes towards mathematics play a critical role in mathematics education as well as science education. Moreover, the study provides empirical evidence that confidence to teach mathematics and science are related and that attitude toward one area influences the other area.

Gresham (2007) conducted a study to investigate the changes in the levels of mathematics anxiety among early/elementary pre-service teachers enrolled in a mathematics methods course over the course of six semesters. The data on the pre-service teachers were collected qualitatively (interviews and discussions) and quantitatively (MARS Likert survey). The MARS was completed at the beginning and at the end of the semester.

Throughout the semester, students participated in documented interviews, discussions, journaling and a field experience. Overall, Gresham found that the mathematics anxiety of pre-service teachers was reduced. Three themes emerged from the data as possible reasons for the reduction in anxiety among the pre-service teachers: (1) the use of manipulatives implemented throughout the course, (2) the personality of the professor, and (3) the use of journal writing.

"Students commented on how the use of journal writing helped them work through their mathematics anxiety while teaching students in their practicum and taking the methods course. Many of the students commented that they now understood topics such as "fractions, decimals, percents, probability and statistics, and algebra" now that is had been presented in a concrete, practical and non-traditional approach (p. 186).

While others commented that their ability to understand mathematics was now enhanced. "The most unanimous and interesting comment was that they felt as though their mathematics anxiety could have been prevented in elementary school, if they had received instruction of mathematical concepts through the use of concrete manipulative" (p. 186).

Charlesworth (1997) suggests that while some change will come through teacher in-service education programs, much of the change will emanate from new teachers who experience instructional practices that use constructivist and integrated approaches to mathematics instruction learned in pre-service education courses. As such, the mathematics methods course for elementary teachers should be a beginning point for mathematics education reform. For it is in this course, that future teachers are guided through the methodology and pedagogy of mathematics. Ball (1990) offers the following

interpretation of methods courses, "Different from a foundation course, a methods course is about more than ideas. It is about developing ways of acting as well as ways of thinking" (p. 7).

In sum, the importance of the elementary education mathematics methods course is three-fold. First, the research suggests that taking a mathematics methods course could lessen mathematics anxiety in prospective elementary teachers and improve the quality of classroom instruction (Sovchik et al, 1981; Battista, 1986; Hembree, 1990; Emenaker, 1996; Harper and Daane, 1998; Tooke and Lindstrom, 1998; Trujillo and Hadfield, 1999; Bursal and Paznokas, 2006; Vinson, 2001; and Gresham, 2007). Secondly, the literature suggests that the use of non-traditional approaches (i.e. open discussion, emphasis on understanding, "real-world mathematics", etc.) in the mathematics methods courses for pre-service teachers can reduce mathematics anxiety (Tobias, 1980; Sovchik et al, 1981; Battista, 1986; Taylor and Brooks, 1986; Schneider, 1988; Hembree, 1990; Thompson, 1992; Emenaker, 1996; Seymour, 1996; Vinson et al, 1997; Harper & Daane, 1998; Tooke and Lindstrom, 1998; Trujillo & Hadfield, 1999; Vinson, 2001). Finally, the mathematics methods course for pre-service teachers should promote the use of non-traditional; more constructivist approaches to teaching mathematics in the elementary school classroom (Ball, 1990; Madsen, 1992; Vinson, 2001; Gresham, 2007). Lindquist and Elliott (1996) suggest, "Probably the most important idea is that preservice teachers should experience mathematics being taught in the way they should teach" (p. 6).

Current research has implemented a broad range of methodological approaches to study the relationships between math anxiety and pre-service education. However, most of the studies used a pre-post test methodology without a control group. Consequently,

the lack of randomized experimental designs makes it difficult to make definite claims about math anxiety and pre-service education though the available evidence does indicate that there is a relationship between methods courses and the reduction of anxiety.

Test Anxiety

Mathematics anxiety is associated with negative attitudes towards mathematics, learning and teaching mathematics, self-confidence, and test anxiety (Bessant, 1985). However, the relationship between test anxiety and math remains unclear. It has been hypothesized that a relationship exists between test anxiety and math anxiety (Sepie & Keeling, 1978; Dew et al, 1983; Dew et al, 1984; McAuliffe & Trueblood, 1986; Kazelskis et al, 2000; Zettle & Raines, 2000). Therefore, when studying mathematics anxiety, a factor to be considered is test anxiety.

One commonly accepted assumption is that test anxiety is more than a dislike of tests. Rather, it supposes that test anxiety is an internal aversion that may interfere with performance (Mandler & Sarason, 1952; Ball, 1995; McKeachie, 1995; Zettle & Raines, 2000). In the groundbreaking research on the topic, Mandler & Sarason (1952) theorized that test anxious individuals reacted to the stresses associated with evaluative situations. That is, test anxiety is a stress present in a testing situation. The researchers hypothesized that high test-anxious individuals would perform more poorly in evaluative situations than low test-anxious individuals. Similarly, Wine (1971) expanded on the Mandler and Sarason hypothesis suggesting that low-test anxious individuals focus on task-related variables (i.e. the test), while high test-anxious individuals focus on perceived evaluation.

What is test anxiety? Liebert and Morris (1967) conceptualized test anxiety as having two components: worry and emotionality. Worry is a cognitive concern associated

with performance and consequences of performance (Liebert and Morris, 1967; Wine, 1971; Deffenbacher, 1980). Emotionality, on the other hand, refers to physiological reactions evoked by stress (Liebert and Morris, 1967; Wine, 1971; Geen, 1980). The physiological changes are a result of the autonomic nervous system in evaluative situations (Spielberger and Vagg, 1995). Research by Liebert and Morris found that the worry component was negatively related to test performance, however, little or no relationship was found between emotionality and performance. The researchers concluded that worry interferes with performance.

Test Anxiety Definition

Since the original study of test anxiety by Mandler and Sarason in 1952, numerous definitions have been submitted for test anxiety. Definitions differ, but what is clear is that test anxiety is a multidimensional construct. For example, Zeidner (1998) defines test anxiety as a construct, which includes physiological and behavioral responses, which accompany concern about possible negative consequences or failure on an examination or similar evaluative situations.

Spielberger and Vagg (1995) discussed test anxiety with regard to state and trait anxiety. State anxiety refers to moments when an individual is experiencing feelings of worry about test performance. Trait anxiety refers to an individual's proneness to anxiety and is a more stable phenomenon. Trait anxiety dictates the way one experiences state anxiety. Spielberger and Vagg (1995) define test anxiety as "The stress associated with examination situations (stressor), the subjective interpretation of a test as more or less threatening for a particular person (threat), and the emotional states that are evoked in test situations" (p. 6). In addition Spielberger and Vagg (1995) suggests that "Test anxious

students tend to perceive examinations as more dangerous or threatening than individuals low in T-Anxiety and experience more intense level of S-Anxiety when taking tests" (p. 6). That is, an individual who is generally more anxious and is taking a test may experience a higher level of state anxiety (i.e. a feeling of worry about test performance) than someone who is generally less anxious.

Sieber (1980) suggests that test anxiety has proven difficult to define and offers the following suggestions for the difficulty: (1) test anxiety has many facets and (2) no theory has yet been formulated that adequately describes test anxiety. Following the review of literature, the researcher has concluded that test anxiety is a multifaceted and complex construct; and that state anxiety (i.e. a situational feeling of worry) is less difficult to assess than and trait anxiety (i.e. a stable and enduring feature).

Test Anxiety and Mathematics Anxiety

Many researchers have viewed test anxiety and mathematics anxiety as related constructs. Some researchers have questioned the separateness of mathematics anxiety and test anxiety (Brush, 1981; Wood, 1988). Brush (1981) conducted a quantitative study using the MARS. The analysis found, that despite a dislike of mathematics and its process, doing calculations or solving problems rarely caused anxiety. On the contrary, it was preparation for mathematics tests and taking mathematics tests that caused students to react with anxiety. Therefore, Brush contends that math anxiety is no more than subject-specific test anxiety.

Wood (1988) conducted a review of the literature on mathematics anxiety and elementary school teachers. In this review, he posed a number of questions. One question, of interest to this study, is whether mathematics anxiety and test anxiety are

separate and distinct constructs. The review summary offered the following: (1) there is doubt whether the two constructs are indeed separate and distinct; (2) mathematics anxiety does not appear to be caused by doing math but rather anticipation, completion and receiving results of a math test; and (3) the constructs are complex and difficult to quantify.

Other researchers have contended that while the two constructs are related; mathematics anxiety and test anxiety are not equivalent (Sepie & Keeling, 1978; Dew, Galassi & Galassi, 1983). Sepie and Keeling (1978) compared performance, general anxiety, test anxiety, and mathematics anxiety of three groups. They hypothesized that "anxiety related to mathematics performance is even more stimulus-specific than is implied by the term test anxiety" (p. 15). The study concluded that, "The activity of mathematics itself appears to generate anxiety reactions among a number of students who are not necessarily highly anxious in other situations. Belief of this highly specific type of anxiety known as mathematics anxiety has been widespread for a long time" (p. 19).

Dew, Galassi and Galassi (1983) investigated the relationship of math anxiety to test anxiety, specifically, the worry and emotionality components of test anxiety. Over 700 university students completed the Mathematics Anxiety Rating Scale (MARS), the Fennema-Sherman Mathematics Anxiety Scale (MAS), the Sandman Anxiety Toward Mathematics (ATMS) and the Test Anxiety Inventory (TAI). The authors investigated whether or not the math anxiety scales measured a construct distinct from test anxiety (worry and emotionality). The data analysis found that while the math anxiety measures were more closely related to one another than to test anxiety. Therefore, Dew et al concluded that the two constructs are not synonymous.

The question is; are mathematics anxiety and test anxiety separate or equivalent constructs? The majority of the literature reviewed on mathematics anxiety and test anxiety asserts that while the two constructs are related; they are separate constructs. Therefore, the answer to the question posed is that mathematics anxiety and test anxiety are separate and distinct constructs.

Test Anxiety, Mathematics Anxiety and Mathematics Performance

A body of research exists on test anxiety, mathematics anxiety and performance (Sepie & Keeling, 1972; Hendel, 1980; Dew et al, 1984; Hembree, 1990; Trujillo & Hadfield, 1999; Zettle & Raines, 2000; Swars et al 2006). From the body of literature, two qualitative studies and three quantitative studies are reviewed. The qualitative studies were selected because they provide a detailed data analysis that contributes to a more in-depth understanding of the variables while the quantitative studies generate a measure of the variables.

Swars et al (2006) conducted a qualitative and quantitative study to investigate mathematics anxiety and mathematics teacher efficacy in elementary pre-service teachers. Twenty-eight students enrolled in a mathematics methods course were administered the Mathematics Anxiety Rating Scale (MARS) and the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) during the final week of the course. The two students with the highest degree of math anxiety and the two students with the lowest degree of math anxiety were chosen to participate in the interview portion of the study. The in-depth interviews were approximately 45 minutes long and were conducted within a week of completing the mathematics methods course.

One theme identified was descriptions of mathematics. The two students with the highest degree of math anxiety focused on mathematics experiences related to procedural knowledge. They recalled memorization of facts, timed tests and pop quizzes. One student recalled, "Doing all those timed tests just killed me"; the other asserted, "I dreaded math and pop quizzes". The two students with the lowest degree of math anxiety focused on mathematics experiences related to reasoning and communication including a dialogue with parents. One student recalled, "I absolutely love numbers. I love working with them and manipulating them to figure out problems." The other student stated, "I grew up around a lot of math. I grew up doing a lot of puzzles and brainteasers."

Trujillo and Hadfield (1999) conducted a qualitative and quantitative study to investigate mathematics anxiety among pre-service teachers. The purpose of the study was to implement in-depth exploration of early school experiences of preservice teachers with high math anxiety levels. Fifty students enrolled in a mathematics methods course were administered the Revised Mathematics Anxiety Rating Scale (R-MARS) (Plake and Parker, 1982). Five of the six students with the highest level of mathematics anxiety participated in in-depth interviews to explore their mathematics anxiety.

From the interviews, mathematics test anxiety was an identified theme. "Mathematics anxiety for all of the participants became most evident when they described how they felt during timed mathematics activities, such as testing situations. Even though some described having some anxiety with other types of tests, mathematics tests seemed to be where their findings of anxiety were magnified" (p. 6).

Below are some examples of responses from the students during the interviews.

"I blanked out during an accounting test in high school. I couldn't answer any of the questions. I was devastated, embarrassed, and scared. I couldn't recall anything. I had to leave and go back later to finish. Now I get nervous and paranoid. I worry about failing. I get an upset stomach and I always think I'm going to blank out again."

"I like math, but I freak on tests. I get low scores due to mechanical errors. After 12 years of low scores, you get a complex and think you're dumb. During a test I get in a frenzy. I go fast, then slow, and then I just can't think. For 111, the final was fifty percent of the grade and it was comprehensive. I had notes, but I couldn't find anything. I got frantic and gave up. It was defeating. I just shut down and couldn't remember anything."

"If I know it, I'm fine. If I am timed, I get nervous and forget everything. I do the ones I know, but then I get stressed that I'm not thinking fast enough and forget. I worry about finishing, and I can't remember it even if I do know it. It is horrible. I get nervous just thinking about it."

"I panic if I'm timed. You are just setting me up to fail. If you tell me I can take all the time I want, but I can only miss five, I can't do it. I just panic and get a stomachache. I don't have good foundations so I have to relearn the concepts. I get frustrated and scared and I don't remember. It is embarrassing. [Standardized tests] determine everything and prove nothing. You are telling me that I am not qualified to be a teacher because of a few questions on a math test? That makes me so mad. I know I'm not going to pass the NTE [National Teachers Examination], it is like a self fulfilling prophecy with me."

Trujillo and Hadfield concluded that all of the preservice elementary teachers in this study had environmental, cognitive, and personality factors that contributed to their levels of mathematics anxiety and their poor performance. Each had negative classroom experiences, little family support, and fears about teaching mathematics. In addition, Trujillo and Hadfield concluded that all of the participants in this study suffered from mathematics test anxiety. The qualitative findings of the two studies discussed above support other research findings. That is, there appears to be a negative relationship between performance and anxiety.

Hendel (1980) conducted a quantitative study to determine the background characteristics correlated to math anxiety, to relate the construct of mathematics anxiety to other measures related to anxiety, and to determine if mathematics anxiety predicts arithmetic performance. The 71 subjects in this study, of which only 2 were males, participated in a mathematics anxiety program at a large university. Participants completed five anxiety scales (Mathematics Anxiety Rating Scale, Suinn Test Anxiety Scale (STABS), the Fear of Negative Evaluation Scale, the Facilitating Anxiety Scale and Debilitating Anxiety Scale, an arithmetic test and an extensive questionnaire.

There were three conclusions of interest. One, the highest correlation found was between mathematics anxiety and test anxiety. Two, the correlations between mathematics anxiety and fear of negative evaluation; and mathematics anxiety and debilitating anxiety suggest that females are anxious about mathematics are also likely to be anxious about a negative evaluation. Moreover, the concern about a negative evaluation is likely to depress mathematics performance. Finally, the results of a multiple regression suggest that the significant variance in the mathematics anxiety scores could be explained by test anxiety and mathematics ability.

Dew et al (1984) conducted a quantitative study to determine the relation of mathematics anxiety to test anxiety, the extent to which math anxiety interferes with performance and the relation of math anxiety to physiological arousal during problem solving. Over 700 undergraduates were screened, 63 were selected by stratified random sampling. The students completed three scales, the Mathematics Anxiety Rating Scale (MARS), the Test Anxiety Inventory (TAI), and the Emotionality and Worry Subscales of Deffenbacher's Post-Task Questionnaire. General math ability was assessed during

this experiment. The students completed the Scholastic Aptitude Test (SAT-Q), the Differential Aptitude Test-Form T (DAT-T) and Form 7G027 of the SAT.

Each student completed three problem sets. Set 1 consisted of 20 arithmetic computation problems and set 2 consisted of 15 word problems. For set 1 and 2, students were told that the purpose of the task was to monitor body reactions to mathematics. In contrast, set 3 was administered under test-like conditions. Students were instructed to work quickly given that there was an allotted time (fifteen minutes) and they were informed that the purpose of the task was to test their ability.

The results of this study suggest that math anxiety measures are more closely related to each other than to test anxiety. Therefore, while test anxiety and mathematics anxiety are related they are not identical. Lastly, only a modest relationship exists between math anxiety and math performance, and between problem solving and physiological arousal.

Hembree (1990) used meta-analysis to integrate the findings of 151 studies in order to deconstruct mathematics anxiety. Four tasks were identified for the research: (1) identify the variables that correlate with math anxiety (math performance, test anxiety and math avoidance), (2) identify variables that exhibit different levels of math anxiety (gender, grade level), (3) identify the relation between mathematics anxiety and performance and (4) examine treatments to reduce math anxiety.

The analysis provided the following conclusions. A number of parallels exist between mathematics anxiety and test anxiety. Both constructs relate to general anxiety, affect performance in a similar manner, respond to similar treatments and improved

performance relates to the relief of the anxieties. In addition, the differences in anxiety level regarding student ability, gender, and ethnicity are similar for both constructs.

However, an analysis of the two constructs revealed that only 37 percent of one construct's variance is predictable from the variance of the other. The remaining 63 percent must be attributed to other sources. Hembree concluded that it is unlikely mathematics anxiety is purely restricted to testing. Rather, he suggests that math anxiety appears to comprise a general fear of contact with mathematics, which includes classes, homework, and tests.

The evidence suggests that (1) higher achievement consistently related to mathematics anxiety and (2) treatment of highly- anxious individuals may restore performance (i.e. their score mirror that associated with low math anxiety individuals). Despite the evidence, there is no compelling evidence that the cause of poor performance is mathematics anxiety.

The discussion on math anxiety and test anxiety leads to a discussion of another factor that may contribute to mathematics anxiety. It has been hypothesized that there is a relationship between mathematics and stereotype threat. Therefore, when studying mathematics anxiety, a factor to be considered is stereotype threat.

Stereotype Threat

It has been hypothesized that a relationship exists between mathematics and stereotype threat (Elliott, 1986; Steele, 1997; Aronson et al, 1999). The stereotype threat research identifies gender, performance (in testing situations) and race as three contributing factors of stereotype threat (Steele & Aronson, 1995; Steele, 1997; Spencer

et al, 1999; Brown & Josephs, 1999; Osborne, 2001; Keller, 2002; Schmader, 2002; Smith & White, 2002; Schmader et al, 2004).

Steele (1997) conducted the original research on stereotype threat. In his groundbreaking research on stereotype threat, Steele hypothesized that societal stereotypes about groups influence performance. Specifically, Steele hypothesized that females contend with negative stereotypes in mathematics, while minority students contend with negative stereotypes in all academic areas. Finally, Steele suggests that these negative stereotypes diminish academic achievement because they interfere with performance and promote "disidentification" (i.e. disengaging from the threatening domain and removing the threatening domain from one's self-identity to protect one's self esteem).

In sum, stereotype threat is contingent upon conditions. That is, the salience of the stereotype threat influences performance, and its impact depend on the context in which it occurs. The theory of stereotype threat describes pressures and threats that affect test performance and academic identities (Steele & Aronson, 1995; Steele, 1998).

Stereotype Threat: A Definition

What is stereotype threat? Steele (1997) defines stereotype threat as "a situational threat - a threat in the air- that, in general form, can affect members of any group about whom a negative stereotype exists" (p. 614). Similarly, other researchers define stereotype threat as a situational predicament; a phenomenon that individuals may experience either: (1) when an individual feels his/her behavior may confirm a negative stereotype about one's group; or (2) when an individual is involved in a situation that may confirm a negative stereotype about one's groups (Spencer et al, 1999; Aronson et

al, 1999). In sum, the definitions reviewed describe stereotype threat as a situational

threat (i.e. state anxiety) in which one worries about confirming a negative stereotype.

Stereotype Threat: A Model

Several features are central to the theory of stereotype threat (Steele, 1997;

Aronson et al, 1998). The first element is that stereotype threat reflects a situational

threat experienced in a situation where the behavior can confirm a negative stereotype.

Given the fact that stereotype threat is conceptualized as situational pressure, it does not

reflect an internalized feeling of inferiority. However, Steele and Aronson (1995) argue

that while stereotype threat is not an internalized feeling of inferiority initially; following

extended exposure to society's negative images about their abilities, individuals are likely

to internalize an "inferiority anxiety".

Stereotype threat does not reflect lack of ability nor does it reflect belief

(acceptance) of the stereotype. Rather, a "Mere awareness of the stereotype and its

alleged relevance to one's performance in a given situation is sufficient, we believe to

arouse the apprehension that disrupts performance and adds anxiety to intellectual

pursuits" (Aronson et al, 1998, p. 87).

The second element is that stereotype threat constitutes a threat to the self or an

aspect of self that is important to self-identification. Aronson et al (1998) proposed that

stereotype threat is more likely to have its strongest effects on individuals who are

heavily invested in or who heavily identify to the domain. Their proposition is based on

the assumption that for a negative stereotype to be threatening, it must be self-relevant.

Although experiments on this element of stereotype threat are only partially completed,

Steele (1997) offers a hypothesis on domain identification and stereotype threat. Steele

suggests, "Not being identified with a domain means that one's experience of stereotype threat in the domain is less self-threatening" (p. 622).

The third element is that stereotype threat is the link between anxiety and academic achievement specifically tests anxiety. The physiological, cognitive and psychological effects of anxiety in testing situations are well documented in the literature. The results indicate that a threat can divert attention away from the task, produce nervousness and uneasiness, impair cognitive functioning and prompt a withdrawal of effort as a self-protective measure (Liebert and Morris, 1967; Wine, 1971; Deffenbacher, 1980; Geen, 1980). These test anxiety results support features of the stereotype threat model. For instance, the theory of stereotype threat suggests that a threat of a negative stereotype interferes with performance because it diverts attention away from the task specifically a test and produces nervousness because the individual's attention is focused on avoiding a stereotype confirmation. In addition, negative stereotypes promote a withdrawal from the domain. Finally, as a result of negative stereotypes, the stereotype threat theory asserts that cognitive ability is compromised and impaired during performance.

The fourth element is that stereotype threat is "disindentification". Disidentification is describes as a psychological disengagement (volitional dimension) from the threatening domain. Steele (1997) defines disidentification as "a reconceptualization of the self and of one's values so as to remove the domain as a self-identity, as a basis of self-evaluation" (p. 614).

Disidentification refers to the tendency of members of stereotyped groups to disidentify with the threatening domain and removing the domain from one's self-identity

to protect self-esteem. That is, disidentification is a self-protective strategy. While disindentification is protective; it is destructive, "Because identification with academics-the extent to which one is affected by one's outcomes in school-is assumed to be crucial for significant levels of achievement (Steele, 1997), the protective disengagement from academics constitutes a serious barrier to the sustained motivation required for high achievement" (Aronson et al, 1998, p.87-88). The concept of "disidentification" theorized by Steele echoes the theory of prefrontal lobe volition presented by Elliott (1983, 1986).

To summarize, stereotype threat theory consists of four elements. Those elements include the situation threat (i.e. the context in which the threat is experienced), the self-identification threat (i.e. the relationship between self and negative stereotypes, volition), the effect of anxiety (i.e. the threat on intellectual performance), and disindentification (i.e. the tendency to disconnect with threatening domains, volition). Theoretically, the elements of stereotype threat interact to undermine the performance and motivation of individuals stigmatized by negative stereotypes, especially females in the area of mathematics and minorities in all academic areas including testing situations (Steele & Aronson, 1995; Steele, 1997; Aronson et al, 1998). Finally, Steele offered the following "stereotyping and its threats are real" (1998, p. 680).

Stereotype Threat and Gender

The stereotype threat research focuses on two groups in particular, females and African Americans. For the purposes of this research study, the group to be considered is females. The reasons for concentrating on females is are three-fold.

One, females accounted for over 50 percent of students on college campuses in 2005. More specifically in 2005, between 54 and 57 percent of college students in the

United States were female (Mather and Adam, 2005; Marklein, 2005). In addition, Mather and Adam (2005) reported a 7 percentage-point gap between female and male college enrollment rates.

Two, females represent the majority of students enrolled in colleges of education (Sells, 1972; Bass, 2007; Mantey, 2007). For example, Bass (2007) reported that males, at the University of Central Florida College of Education, represent about 18 percent of students. According to the university's Office of Institutional Research, this percentage is slightly below the national percentage.

Three, this is a study of mathematics anxiety in preservice teachers. The literature suggests that gender stereotypes impair female performance on tasks for which they are negatively stereotyped, such as mathematics (Spencer et al, 1999; Brown & Josephs, 1999; Schmader, 2002; Schmader et al, 2004); and the literature also suggests that pre-service teachers, the majority of whom are female, experience higher levels of mathematics anxiety than males (Lazarus, 1974; Sovchik et al, 1981; Kelly & Tomhave, 1985; Battista, 1986; Burton, 1986; Wood, 1988; Harper & Daane, 1998; Trujillo & Hadfield, 1999; Haylock, 2001; Vinson, 2001; Bursal & Paznokas, 2006; and Swars et al 2006).

Stereotype Threat: Math Anxiety, Test Anxiety and Mathematics Performance

Gender mathematics stereotypes are widely held and accepted in society. For example, about fifteen years ago, Mattel introduced its second talking Barbie doll. The doll's vocabulary included the statement, "Math class is hard." The statement was removed from Barbie's vocabulary following objections from the public, the media and particularly the American Association of University Women (AAUW). Clearly, Mattell

was working under the assumption that mathematics is difficult for girls (Smith & White, 2002) or that girls are not good at math or at the very least not as good at math as boys. This example suggests that these widely held and accepted math gender stereotypes help to create and ultimately maintain gender differences in mathematical performance.

The research on stereotype threat examined the theory on females and math performance and academic performance of minorities. However, this research study and literature review concentrates on stereotype threat theory and female math performance. The results on these studies have demonstrated that negative stereotypes directly impair female's math performance (Spencer et al, 1999; Brown & Josephs, 1999; Osborne, 2001; Schmader, 2002; Keller, 2002; Smith & White, 2002; Inzlicht & Ben-Zeev, 2003).

Spencer et al (1999) conducted a study to examine stereotype threat and math performance of females as it relates to test difficulty. The study consisted of two experiments. The first experiment examined female and male performance on difficult math tests and easy math tests. Participants in this study were identified as having a strong mathematics background. The study found that females underperformed on the difficult tests when compared to males. However, on the easier test, there was no significant difference between female performance and male performance.

The second experiment was similar to the first study; however, the present study examined the effects of stereotype threat on performance. Again, participants in the study were identified as having a strong mathematics background. Participants were randomly assigned to one of two experimental conditions: a gender difference condition or a no-gender difference condition. In the gender difference group (stereotype threat), participants were told that the test had shown gender differences in the past. On the

contrary, participants in the no-gender difference group were told that the test had not shown gender differences.

The results revealed that females in the gender difference group (stereotype threat group) significantly underperformed on the test as compared to males. Whereas, the performance of females in the no gender difference group equaled the performance of males on the test. These results provide strong support for the theory of stereotype threat.

Brown and Josephs (1999) conducted a study on stereotype threat and gender difference in math performance. Female and male participants were given a math test. Results indicate that females who were informed that the test would determine if their math ability was weak performed worse than females who were informed that the test would determine if their math ability was strong. The pattern for males in the study was opposite. Males performed better when they were told that the test measure mathematics strength than when they were told that the test measure mathematics weakness.

The results of this experiment reinforce the gender-related stereotypes about mathematics and indicate that stereotype threat can be both positive and negative. Moreover, the results suggest that if you are a member of a group that is negatively stereotyped (i.e. females and math inability), stereotype threat hampers performance. On the other hand, if you are a member of a positively stereotyped group (i.e. males and math ability) stereotype threat enhances performance.

As previously discussed, Steele and his colleagues, propose that stereotype threat is more likely to have its strongest effect on individuals who highly identify with a group. To test this element of stereotype threat, Schmader (2002) conducted a study to examine the effect of stereotypes on performance as it applies to social identification. Both

females and males participated in this study. The participants were randomly assigned to one or two conditions to complete a math test in which gender was either linked to performance or gender was not linked to performance. In addition, participants in this study identified whether they had high gender identification and low gender identification. Gender identification was examined as a continuous variable in the research design. The results found that females with high gender identification performed worse than males on the math test when they were told that the test produced gender differences, whereas, females with low gender identification performed as well as males on the math test.

Factors other than group identification influence performance, for example Keller (2002) conducted a study to examine situational aspects in testing and stereotype threat. Seventy-five students participated in this study (37 females and 38 males). The participants were asked to complete a math test with 20 questions and following the completion of the test, the participants were asked to rate the difficulty of the test.

During the test phase of the experiment, half of the participants were read the following script, "The following math test is a collection of questions which have been shown to produce gender differences in the past. Male participants outperformed female participants" (p. 195). As expected and similar to other research findings, Keller found that female participants in the negative stereotype threat condition underperformed in comparisons to females in the control condition. In addition to underperforming on the math test, the negative stereotype resulted in increased self-handicapping tendencies in females. That is, the stereotype threat elicited a need for females to self-protect.

Smith and White (2002) conducted a study to examine stereotype threat on mathematical performance. Experiment one is of interest to this research study because the researchers exposed participants to deliberate and non-deliberate stereotype threat. All seventy participants were white females. The participants were randomly assigned to one of three experimental conditions: (1) they were told that males outperformed females in mathematics (explicit stereotype threat); (2) they were told that males and females perform at the same level in mathematics (nullified stereotype threat); and (3) they were given the test under "normal" conditions with no instructions (implicit stereotype threat). The results of the study were as follows. Participants in the explicitly activated stereotype threat group (i.e. condition 1) performed worse than participants in the nullified stereotype threat groups (i.e. condition 2); while participants in the implicitly activated stereotype threat group (i.e. condition 3) performed similarly to participants in the explicated activated stereotype threat group.

These findings are similar to other research studies on stereotype threat and gender performance. However, "For the first time, it is shown that both explicitly and implicitly activated stereotypes are equally harmful to performance" (Smith and White, 2002, p. 184).

Inzlicht and Ben-Zeev (2003) conducted a study to examine the effects of stereotype threat in private settings. Participants were female undergraduate students at an Ivy League university. At the beginning of an introduction to psychology course one semester, one hundred fifteen potential participants completed the Mathematics Identification Questionnaire (MIQ) and self-reported their Math SAT scores.

Of the 115 potential participants, "54 students were selected on the basis of having scored above the theoretical midpoint of the MIQ (*M* 6.31, *SD* 0.73) and having scored 570 or above (range 570 – 800) on the Math portion of the SAT (*M* 710.74)" (p. 798). In addition, given the research that stereotype threat is most harmful to those individuals who most identify with the threatened domain only students who were highly math identified were selected to participate in this study.

Fifty-four participants were randomly assigned to a group and asked to complete a math test. Specifically, participants were assigned to one of two groups and either one of two conditions. The groups included a same-gender group (3 females) or a mixed gender group (1 female and 2 males). In one of the conditions, participants were told that their math test score would be shard with others (public setting) while participants in the other condition were told that their math test score would not be shared with others (private setting).

The results of this study found that even in a private setting, females who believed that they were being tested in a stereotype threat domain showed impaired performance as compared to females who believed that they were being tested in a non-stereotype threat domain and that perhaps the effects of stereotype threat on female math performance are not strictly driven by concerns of negative stereotypes. The implications of this study suggest that that gender math stereotypes may be internalized resulting in negative consequences (i.e. poor performance) and that other factors may be contributing to female math performance.

In addition, research on the relationship between stereotype threat and math performance has examined the role of anxiety. That is, the research examined anxiety as

an intermediary for the stereotype threat and math performance relationship (Aronson et al 1999; Spencer et al, 1999; Osborne, 2001; Keller & Dauenheimer, 2003). Research studies on anxiety as an intermediary for stereotype threat and math performance have yielded mixed results. Some researchers found that anxiety did not mediate stereotype threat (Aronson et al 1999; Keller & Dauenheimer, 2003), while others found partial support that anxiety mediated stereotype threat (Spencer et al, 1999).

In an effort to contribute to the literature on anxiety and stereotype threat, Osborne (2001) conducted a study to test whether anxiety could partially explain the relationship between race and achievement, gender and achievement, gender and anxiety and anxiety and achievement test scores. The goal of the study was to examine the theory of stereotype threat and factors that may contribute to achievement within the contexts of testing.

In the article, Testing Stereotype Threat: Does Anxiety Explain Race and Sex Differences in Achievement, Osborne reported the following results: (1) Gender and Achievement: males outscored females on math achievement tests, (2) Gender and Anxiety: males showed significantly lower levels of math anxiety than females and (3) Anxiety and Achievement: the multiple regression indicated a negative relationship between anxiety and achievement test scores. Females scored higher than males on the anxiety variable and differences in anxiety in part accounted for gender difference in math performance. Finally, Osborne clearly demonstrated that as anxiety increased achievement test performance decreased.

The stereotype threat literature reviewed can be summarized in five points: (1) when gender math stereotype is salient, females perform worse then males on math tests;

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(2) when stereotype threat is reduced, females and males perform equally well on math tests; (3) when females were not informed that the test was a measure of mathematical ability, they perform as well as males on math tests; (4) when females are faced with negative stereotypes about their math performance, the negative stereotype threat elicits s a need to self-protect; and (5) female performance on math tests may be the result of internalized stereotypes (i.e. "internalized anxiety"). The literature on stereotype threat is relatively new and still emerging. Yet, there is sufficient evidence to support stereotype threat as a viable and important theory not only in the arena of academic research, but also for educational practice.

CHAPTER 3

METHODOLOGY

Participants

The population, to whom this sample generalizes, are elementary education majors at colleges and universities throughout the country. The study population consisted of College of Education students at Louisiana universities located in the southern region of the state. Given that university education programs adhere to national standards, it is assumed that the education programs and the sample are reflective of most education programs in the United States.

The study sample consisted of 132 university students in Colleges of Education. Thus, the sampling frame will meet the following criteria: (a) potential subjects are College of Education students and (b) the programs chosen (i.e. College of Education) are certified by the National Council for Accreditation of Teacher Education (NCATE).

Research Design

The intent of this section is to identify the research design and to discuss the types of quantitative research used in this study. An experimental design was chosen for this research study (see Table 1). In an experimental design, the experimenter manipulates one or more variables in an attempt to establish a relationship (Goodwin and Goodwin, 1996). The hallmark of an experimental research design is random assignment.

Two types of quantitative research: experimental and correlational research will be implemented. This design begins with the random assignment of subjects to three different experimental conditions: math anxiety, test anxiety and stereotype threat. This study capitalized on the strengths of such a design (i.e. limits the threats to internal

validity with respect to single group threats), while at the same time, introducing the

notion of controlling for the 'signal' (i.e. the key variable of interest) to 'noise' (i.e. ratio

(Trochim et al., 2007).

The experimental manipulation is the independent variables (i.e. introduction of

math anxiety, test threat and stereotype threat as instructions to the three groups). This

study measures and deconstructs the confounding variables of anxiety. The dependent

variable is performance. See the table below for an explanation of the research variables

in this research study's experimental design.

Table 1: Explanation of the Variables

Assignment (R)	Treatments (X)	Variable	Observation (O)	Observation (O)
Random	Math Anxiety	Performance Task	Test Anxiety Inventory-TAI	Mathematics Anxiety Rating Scale-Revised MARS-R
Random	Test Threat-X_1	Performance Task	Test Anxiety Scale-TAI	Mathematics Anxiety Rating Scale-Revised MARS-R
Random	Stereotype Threat-X_2	Performance Task	Test Anxiety Scale-TAI	Mathematics Anxiety Rating Scale-Revised MARS-R

Instruments

The participants in this study completed two Likert scale questionnaires: (1)

Mathematics Anxiety Rating Scale-Revised (Fennema and Sherman, 1976) and (2) Test

Anxiety Inventory (Spielberger, 1980). The two scales chosen are based on their use in

the literature and relevance to this particular study. In addition, the participants

completed a mathematics performance task and a short questionnaire to gather biographical and educational background information.

The Mathematics Anxiety Rating Scale- Revised (MARS-R) (Fennema & Sherman, 1976) is an instrument adapted from the Fennema Sherman Mathematics Attitudes Scales. Specifically, the MARS-R uses 10 items to measure mathematics anxiety for college students. Betz (1978) offers the following description of the MARS-R, "The scale is intended to assess feelings of anxiety, dread, nervousness, and bodily symptoms related to doing mathematics" (p. 442). Half of the items on this scale are worded positively and the other half is worded negatively. The participants rate from five possible choices: strongly agree, agree, undecided, disagree and strongly disagree. The following numeric values are assigned to the positively phrased questions strongly disagree = 5, disagree = 4, undecided = 3, agree = 2, and strongly agree = 1. The following numeric values are assigned to negatively phrased questions so that high scores indicate a positive attitude: strongly disagree = 1, disagree = 2, undecided = 3, agree = 4, and strongly agree= 5. Scores on the Mathematics Anxiety Scale-Revised (MARS-R) range from 10 to 50 and the higher the score, the higher of level of math anxiety. The use of the MARS-R in this study is two-fold: one, its prevalence in the literature and two, its reliability coefficients particularly with university students.

Charles Spielberger (1980) developed the Test Anxiety Inventory (TAI). It is a self-report inventory commonly used to measure test anxiety and consists of 20 items. The TAI measures two components of test anxiety: worry and emotionality. Each of the components is a response to a situation. Worry is the cognitive component of anxiety while emotionality is the affective and behavioral component. That is, worry is

characterized as concern about one's performance, one's perceived lack of competence (failure) and one's comparison to others. Emotionality, on the other hand, is characterized by one's reaction to a situation, particularly one's reaction to a test.

The participants taking the TAI choose from four possible choices: almost never =1, sometimes = 2, often = 3, and almost always = 4 that represent how often they experience the feeling described in each statement. The Test Anxiety Inventory (TAI) has a minimum score of 20 and a maximum score of 80. Scoring weights for 19 of the 20 items are weighted 1 through 4, a score of 1indicating low test anxiety ("I generally feel anxious toward test"- almost never) and a score of 4 indicating high test anxiety ("I generally feel anxious toward test"- almost always). Specifically, items 2 through 20 are weighted 1, 2, 3 and 4. The remaining item, item 1 was given reversed weights 1 for high anxiety to 4 for low anxiety. The purpose for using the TAI is to account for variance in math performance; and examine the relationship between test anxiety and math anxiety.

The mathematics task or math performance task are a subset of questions from the Massachusetts Tests for Educators Licensure (MTEL). The MTEL is specifically designed for prospective teachers. Currently, the Commonwealth of Massachusetts uses this test for teacher certification and licensure. The MTEL was chosen for the population of students utilized in this study.

The General Curriculum Test, formerly Elementary Education Test, is a sub-test of the MTEL. The General Curriculum Tests consists of five areas: language arts, mathematics, history and social science, science and technology/engineering and child development; and 100 multiple choice items and 2 open response items. For this study, the subarea of interest is mathematics. The National Evaluation Systems (2002)

identified four test objectives for the mathematics subarea: (1) understand and apply number properties and number representations, (2) understand and apply number operations to represent and solve problems, (3) understand and apply patterns, relations, algebra, and principles of geometry and (4) understand and apply concepts and methods of data analysis, statistics and probability. All of the mathematics questions on the sample MTEL are presented in the multiple choice format and each correct response is given a score of 1.

The mathematics questions on a General Curriculum Practice Test of MTEL were reviewed by a College of Education elementary mathematics professor at the University of Massachusetts Amherst. Following the review, one question was selected as representation for each of the five standards: number operations, algebra, geometry, probability and measurement. The five questions selected were presented to the participants during the second phase of the experiment. Following the MTEL scoring instructions, this study assigned a score of 1 for correct responses and the possible scores ranged from 1 to 5 for the math performance test.

Measurement

Reliability of Instruments

Reliability is "The degree to which a measure is consistent or dependable; the degree to which it would give you the same result over and over again, assuming the underlying phenomenon is not changing" (Trochim and Donnelly, 2007, p. 315).

Betz (1978) calculated the reliability of the Mathematics Anxiety Rating Scale-Revised using the split-half method. There are three steps to calculating the split-half reliability: (1) divide the test into equivalent halves, (2) compute a Pearson r between scores on the two halves of the test, and (3) adjust the half-test reliability using the Spearman-Brown formula. The Spearman-Brown reliability formula is commonly used to predict the reliability of a test after changing the test length. Betz (1978) calculated the reliability of the Mathematics Anxiety Scale-Revised and reported a coefficient of .92. Therefore, the scale is considered to be a reliable instrument for measuring anxiety in college students.

Speilberger (1980) calculated alpha coefficients for the TAI on undergraduate college students. An alpha coefficient of .94 was reported for males and .95 was reported for females. Therefore, the scale is considered to be a reliable instrument for measuring test anxiety in college students.

Validity of Instrument

There is evidence of validity on the Massachusetts Tests for Educator Licensure (MTEL). For the purposes of this study, the type of validity of most interest is content validity. Content validity is the extent to which the items on a test look like the concept.

Goodwin and Goodwin (1996) suggest that content validity is more judgmental than empirical.

Procedures

The University of Massachusetts Amherst Human Subjects Review Board granted approval to conduct the study.   Following the approval to conduct the research study, the researcher contacted College of Education deans, chairpersons, and professors at various universities in Louisiana to obtain permission to conduct the research during the summer of 2008.

Experiment

The experiment for this study was conducted in two phases. Phase one and phase two were completed during one contact visit with the participants. The instructions for each phase are described below.

Phase One:

1. The participants assembled in a large room and were randomly assigned a number.

2. Following a brief introduction of the researcher and a description of the study was given, and the participants completed a consent form.

3. The participants next completed a personal data questionnaire to gather demographic and attitude data.

Phase Two:

1. The participants were divided into one of three groups (math anxiety (control group), test threat and stereotype threat) by random assignment for the math performance task.

2. The math anxiety group received the math performance task and was read the following instruction "I would like each of you to answer the questions to the best of your ability".

3. The test threat group received the math performance task and was read the following instructions "This is a test of your math ability and the answers will be scored for correctness. Calculators are not allowed and you must work alone. You have thirty minutes to complete this test".

4. The stereotype threat group received the math performance tasks and was read the following instructions "Please answer the questions on the test to the best of your ability. Your scores will be compared to male students at the University of Massachusetts Amherst who also completed this task".

5. Following the completion of the performance tasks, each participant completed the Mathematics Anxiety Scale-Revised (Fennema and Sherman, 1976) and the Test Anxiety Inventory (Speilberger, 1980).

6. Participants were released from the study once they have completed the math performance task and the scales.

Sequence of Data Analysis

First, the reliability of the scales was calculated using Cronbach's alpha. "This reliability coefficient indicates the degree of homogeneity in the items; a high coefficient tells us that the items tend to be measuring the same characteristic of the respondents, while a low coefficient means that the items are disparate in what they are measuring (Goodwin and Goodwin, 1996, p. 79). Cronbach's alpha was applied to the scales to determine their reliability. Cronbach's alpha measures consistency within the instrument.

That is, it is a measure of how well each item in a scale correlates with the remaining items. If the inter-item correlations are high, then there is evidence that the items are measuring the same construct. Cronbach's alpha uses the responses to provide information regarding the extent to which the questionnaire items that were planned to measure the same variable are actually related to one another. There is a general rule of thumb, that a Chronbach's alpha in the .50s is not useful for analysis. When it reaches the .60s it is of marginal usefulness. It is probably best to use those variables that have a Cronbach's alpha in the .70s or better.

Next, with the significance level set at $p < .05$, a Pearson correlation was calculated for the MARS-R and the TAI. The Pearson correlation coefficients measured the relationship between variables. A correlation is a statistical summary and a measure of correlation is used to describe the relationship between two variables. Glass and Hopkins (1996) suggests that a "Correlation coefficient allows us to compare the strength and direction of association between different pairs of variables" (p. 106). It is important to note that the direction is not the same as the strength of the relationship. It could be strong or weak in either direction. The value of the Pearson correlation coefficient is represented as r. In addition to providing a definition for correlation coefficients, Glass and Hopkins (1996) discuss the values of r. "The value of r can range from -1.0 for a perfect inverse or negative relationship, through 0 for no correlation, and up to 1.0 for a perfect direct or positive relationship" (p. 106). Finally, Hinkle et al (2003) explain that as a general rule of thumb correlations less the .30 indicated little relationship between variables.

Finally, an analysis of the variance (ANOVA) was used to analyze the data collected during phase two of the experiment. An ANOVA is used to test for differences among two or more independent groups. The purpose of this data analysis is to test the mean differences in performance of the three subgroups groups. In addition, a post-hoc analysis was conducted to determine which group means differ significantly from others. Finally, based on participant responses on the scales and the personal questionnaire, the researcher analyzed the background and attitude data from the questionnaire. Specifically, the data analyses for this study were designed to:

1) Identify descriptive statistics for the instruments (MARS-R and TAI) and the math performance task used in this study.

2) Examine the reliability of the two scales (MARS-R and TAI) used in this study.

3) Analyze the relationship between math anxiety, test anxiety and performance.

4) Analyze the relationship between math anxiety, test anxiety, performance and gender.

5) Analyze descriptive statistics from the personal data questionnaire.

6) Compare the mean differences in performance of the three subgroups (math anxiety, test anxiety and stereotype threat) including a post hoc analysis to determine which group mean differs significantly.

CHAPTER 4

REPORT OF DATA AND DATA ANALYSIS

The purpose of this research was to explore the relationship between math anxiety test anxiety, stereotype threat, and performance in pre-service teachers. Specifically, the effects of mathematics anxiety, test anxiety, and stereotype threat on math performance were examined.

<u>Statistical Methods</u>

The data analysis for this study utilized descriptive statistics and inferential statistics. Descriptive statistics include measures of central tendency (mean), variability (standard deviation) and relationship. Pearson correlation coefficients were calculated to measure the degree of relationship or association between the variables; and used to interpret the results of the scale surveys (i.e. MARS-R and TAI) and questions answered by the subjects on the performance task. Specifically, the Pearson correlation coefficient was used to measure the relationship between mathematics anxiety and performance; and test anxiety and performance of pre-service teachers' self-reported frequencies and a mathematics performance task.

Cronbach's alpha was calculated to measure the reliability of the two scales (MARS-R and TAI). "This reliability coefficient indicates the degree of homogeneity in the items; a high coefficient tells us that the items tend to be measuring the same characteristic of the respondents, while a low coefficient means that the items are disparate in what they are measuring (Goodwin and Goodwin, 1996, p. 79).

Inferential statistics (T-tests and ANOVA) estimate population parameters based on a random sample of subjects. T-tests were conducted to compare the means between

males and females on the two scales and in the stereotype threat experimental group; and the performance task and self-reported attitude items on the personal data questionnaire. An analysis of variance (ANOVA) was used to compare the mean difference between the groups (math anxiety group, test threat group and stereotype threat group) with the dependent variable (performance task). The ANOVA compares means between the variables. Following the ANOVA, a post-hoc analysis was conducted to determine which of the group means differ significantly from others.

Results

Personal Data Questionnaire

Frequencies were calculated from 132 participant responses on the personal data questionnaire are presented below. Tables 2 and 3 provide demographic information on the participants in this study.

Table 2: Gender

Gender	N
Females	108
Males	24

Table 3: Race/Ethnicity

Race/Ethnicity	N
Caucasian	99
Black/African American	29
Hispanic	1
Native American	2
Other	1

Table 4a presents the frequency distribution of female responses to the attitude items on the personal data questionnaire. While Table 4b, presents the frequency responses of the males to the attitude items on the personal data questionnaire. Tables 4c and 4d present the results of the t-test for the attitude items.

Table 4a: Attitude Items for Females

Rating	Strongly Agree or Agree	Strongly Disagree or Disagree
Item 1: Math is my least favorite subject in school.		
N	66	42
Percentage	62%	39%
Item 2: Math is my least favorite subject to teach in the classroom.		
N	54	54
Percentage	50%	50%
Item 3: A high level of mathematics anxiety best describes me.		
N	57	51
Percentage	53%	47%
Item 4: A high level of test anxiety best describes me.		
N	60	48
Percentage	56%	44%

Over 60% of the females surveyed identified math as their least favorite subject in school and 50% identified mathematics as their least favorite subject to teach in the classroom. Of the females surveyed, 53% identified themselves as someone with a high level of mathematics anxiety while over 50% identified themselves as someone with a high level of test anxiety.

Table 4b: Attitude Items for Males

Rating	Strongly Agree or Agree	Strongly Disagree or Disagree
Item 1: Math is my least favorite subject in school.		
N	9	15
Percentage	28%	63%
Item 2: Math is my least favorite subject to teach in the classroom.		
N	11	13
Percentage	46%	40%
Item 3: A high level of mathematics anxiety best describes me.		
N	8	16
Percentage	33%	67%
Item 4: A high level of test anxiety best describes me.		
N	8	16
Percentage	33%	75%

Only 28% of the males surveyed strongly agree/agree with the statement "Math is my least favorite subject in school". For the item, "Math is my least favorite subject to teach in the classroom" male responses were 46% strongly agree/agreed while 40% strongly disagree/disagree. Of the males surveyed 67% identified themselves as someone with a low level of mathematics anxiety and 75% identified themselves as someone with a low level of test anxiety.

Table 4c: T-Test Group Statistics for Attitude Items by Gender

	Gender	N	Mean	Standard Deviation	Std. Error Mean
Math is my least favorite subject	Female	108	2.77	1.047	.101
	Male	24	2.33	.917	.187
Math is my least favorite subject to teach	Female	108	2.59	.938	.090
	Male	24	2.54	1.215	.248
A high level of math anxiety best describes me	Female	108	2.62	.993	.096
	Male	24	2.21	.884	.180
A high level of test anxiety best describes me	Female	108	2.62	.817	.079
	Male	24	2.29	.806	.165

Table 4d: T-Test for Attitude Items

	Levene Test for Equality of Variance		T-test for Equality of Mean					95% CI	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff.	Std. Error of Diff.	Lower	Upper
Math is my least favorite subject	1.442	.232	1.882	130	.062	.435	.231	-0.22	.893 .
Math is my least favorite subject to teach	6.749	.101	.227	130	.820	.051	.224	-.392	.494
A high level of math anxiety best describes me	2.339	.129	2.019	37	.050*	.412	.204	-.001	.826
A high level of test anxiety best describes me	.396	.530	1.787	130	.076	.329	.184	-.035	.693
			1.882	34.307	.080	.329	.182	-.042	.699

* *t* value is significant at the .05 level of significance

Table 4c provides the group statistics. Table 4d presents the findings of the t test.

Those findings include the Levene's Test for Equality of Variances, a *t* value, the degrees

of freedom, a .05 significance level and a 95% confidence interval. If the Levene's Test

is significant (the "Sig." value is less than .05), the two variances are significantly

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different. If it is not significant (the "Sig."value is greater than .05), the two variances are not significantly different from each other.

One attitude item (A high level of math anxiety best describes me) on the personal data questionnaire yielded a significant difference between males and females, for females the (M=2.62, SD= .993) and for males (M=2.21, SD= .884). The data yielded a *t* (2.019) with df (37) and a p value of .050. This *t* value also falls outside the 95% confidence interval. The null hypothesis that there is no relationship between females and males and their self-reported level of math anxiety is rejected.

Finally, the personal data questionnaire asked participants whether they had completed a mathematics methods course. "A math methods course is about mathematics. It is also about children as learners of mathematics, about how mathematics can be learned - - taught, and how classrooms can be environments for learning math" (Ball, 1990, p. 6). A dichotomous response format was used for this question. Table 5 presents the responses by gender.

Table 5: Mathematics Methods Course

Responses	Females	Males
Item: Did you complete the mathematics methods course?		
Yes		
N	48	5
Percentage	44%	21%
No		
N	60	19
Percentage	56%	79%

Most of the participants in this study had not completed a mathematics methods course.

Scales and Performance Task

Frequencies were calculated from 132 participant responses on the scales (MARS-R and TAI) and the mathematics performance task (five questions in multiple choice format). Tables 6 and 7 provide a distribution of the scores by gender.

Table 6: Mathematics Anxiety Rating Scale-Revised Composite Scores for Females and Males

	Females	N	Percentage	Males	N	Percentage
Score Interval						
10-19		12	11%		6	25%
20-29		30	28%		10	42%
30-39		26	24%		5	21%
40-50		40	37%		3	13%

Over 61% of the females had a MARS-R score of 30 or higher, while 34% of the males scored 30 or higher. A chi square test was used to measure the distribution of the variation between the expected and observed scores for males and females across the intervals of MARS-R.

The results of the above analysis was x^2 (3, N=129) = 45.34, p>.001. We can reject the null hypothesis and conclude that there is a statistic significant difference between females and males and the MARS-R.

Table 7: Test Anxiety Inventory Composite Scores for Females and Males

	Females	*N*	Percentage	Males	*N*	Percentage
Score Interval						
20-29		19	18%		10	43%
30-39		37	35%		6	26%
40-49		33	31%		4	17%
50-59		11	10%		1	4%
60-69		5	5%		2	9%
70+		1	1%		0	0%

The majority of females surveyed scored between 30 and 60 on the TAI, while the majority of males surveyed scored between 20 and 40. These scores indicated that female participants had a higher level of test anxiety following the mathematics performance task than the male participants.

A chi-square test was used to examine differences on the TAI between females and males. The results x^2 (5, N=129) = 59.24, p<. 001. We can reject the null hypothesis and conclude that there is a statistically significant relationship between females and males and the TAI.

Performance Task

The performance task, which consisted of 5 multiple choice mathematics questions, was completed by each of the participants. The composite scores on the performance tasks are presented in Table 8.

Table 8: Mathematics Performance Task Composite Scores for Females and Males

	Score Interval	N	Percentage
Females	0-2	42	39%
	3-5	66	61%
Males	0-2	7	29%
	3-5	17	71%

39% of females in the study scored between 0 and 2 on the mathematics performance task, while only 29% of males scored between 0 and 2 on the performance tasks. Males outscored females by ten percent in the 3-5 score interval (71% for males to 61% for females).

A chi-square test was used to examine differences on the math performance task between females and males. The results x^2 (3, N=132) = 2.69, p>.001. We can accept the null hypothesis and conclude that there is not a statistically significant relationship between females and males on the mathematics performance task.

Stereotype Threat Group and Performance Task

Table 9: Performance Task Means for Females and Males in the Stereotype Threat Group

	N	Mean	Std. Deviation
Females	35	2.7714	1.35225
Males	9	3.1111	1.45292

The scores on the performance task for the stereotype threat experimental group ranged from 0 to 5, for females (M=2.7714, SD= 1.35225) and from 1 to 5, for males

(M=3.1111, SD= 1.45292). The mean score for males in the stereotype threat group on the performance task was higher than the mean score for females in the stereotype threat group. A further analysis, on the stereotype threat group performance task data, of the mean scores, revealed that the scores for females was normally distributed, however the mean scores for males was not normally distributed. The mean score for males consisted of outliers that skewed the distribution.

Table 10: T-Test on Gender and the Performance Task of the Stereotype Threat Group

	t	df	Sig.	Mean Diff.	95% C.I.	
					Lower	Upper
Gender	13.826	43	.000	2.84091	2.42265	3.2553
Performance Task	29.188	43	.000	1.79545	1.6714	1.9195

The gender data yielded a *t* (43) =13.826, p<.05 and the performance task data yielded a *t* (43) =29.188, p<.05. These findings suggest that a significant t difference exists between gender and scores on the performance task in the stereotype threat group.

Mathematics Anxiety, Test Anxiety and Performance Task: Descriptive Statistics

Descriptive statistics were calculated for the variables: math anxiety, test anxiety and the mathematics performance task are presented in Table 11.

Table 11: Descriptive Statistics for Variables in the Study

Variable	Minimum Possible Score	Maximum Possible Score	Minimum Obtained Score	Maximum Obtained Score	Mean	Standard Deviation	Cronbach's Alpha
Math Anxiety	10	50	10	50	31.7879	11.07437	.953
Test Anxiety	20	80	22	71	38.4651	11.02061	.926
Math Performance Task	0	5	0	5	2.8636	1.40757	--

Correlations Among the Variables in the Study

The correlations among the anxiety and performance variables are presented below in Table 12. Table 13 presents the correlations between the Mathematics Anxiety Rating Scale-Revised (MARS-R) and the Test Anxiety Inventory (TAI).

Table 12: Anxiety Variables and Performance Task Correlations Coefficients

Variable	Math Anxiety	Test Anxiety
Math Performance Task	-.320	-.170
Sig.	.000**	.027*

*Correlation is significant at the .05 level of significance
** Correlation is significant at the .01 level of significance

Each correlation on the variables (math anxiety, test anxiety and performance) was significant at the $p< .05$ level of significance and the $p< .01$ level of significance. One of the assumptions of the study was that pre-service teachers with high levels of anxiety would have low scores on the mathematics performance task. Such a relationship would be demonstrated by a negative correlation. That is, as anxiety increased, the scores on the performance task would decrease. The data yielded two negative correlations between math anxiety and performance of -.320 ($p< .01$); and test anxiety and performance of -.170 ($p< .05$).

Table 13: MARS-R and TAI Correlations Coefficients

Scales	MARS-R	TAI
MARS-R	1	.432
TAI	.432	1
Sig.	.000**	.000**

** Correlation is significant at the .01 level of significance

The correlation between the (MARS-R and TAI) was significant at the $p < .01$ level of significance. The data yielded a positive correlation between the MARS-R and the TAI of .432 ($p < .05$). The correlation coefficient r of .432 yields a coefficient of determination (r^2) of .18. That is in this case, the r^2 indicates that 18% of the variance is accounted for by the relationship.

Mathematics Anxiety, Test Anxiety, Stereotype Threat and Performance

The data analysis on performance and the three groups will be presented below. Specifically, Table 14 presents the descriptive statistics; table 15 presents the inferential statistics (i.e. ANOVA); and table 16 the post-hoc analysis.

Table 14: Descriptive Statistics for the Instruments and Experimental Groups

	N	Minimum	Maximum	Mean	Std. Deviation
Groups					
Math Anxiety					
Test Anxiety Scale	45	24.00	71.00	41.7111	11.60451
Math Anxiety Scale	45	10.00	50.00	33.1556	10.82286
Performance Task	45	0.00	5.00	2.8889	1.52587
Test Anxiety					
Test Anxiety Scale	41	23.00	67.00	37.0244	9.76598
Math Anxiety Scale	43	10.00	50.00	30.4419	10.50012
Performance Task	43	0.00	5.00	2.8605	1.35544
Stereotype Threat					
Test Anxiety Scale	43	22.00	62.00	36.4419	10.98766
Math Anxiety Scale	44	10.00	50.00	31.7045	11.92921
Performance Task	44	0.00	5.00	2.8409	1.36302

Student responses from the control group on the MARS-R ranged from 10 to 5 (M=33.15, SD=10.82), the TAI scores ranged from 24 to 71 (M=41.71, SD= 11.60 and mathematics performance task score ranged from 0 to 5 (M=2.88, SD=1.52). Student responses from the test anxiety group on the MARS-R ranged from 10 to 50 (M=30.44, SD=10.50), the TAI scores ranged from 23 to 67 (M=37.02, SD = 9.76) and the performance task score ranged from 0 to 5 (M=2.86, SD=1.35). Student responses from the stereotype threat group on the MARS-R ranged from 10 to 50 (M=31.70, SD=11.92), the TAI scores ranged from 22 to 62 (M=36.44, SD = 10.98) and the performance task score ranged from 0 to 5 (M=2.84, SD=1.36).

The mean score on the Test Anxiety Inventory (TAI) was higher than the mean scores on the Mathematics Anxiety Rating Scale-Revised (MARS-R) across each of the

random groups. The mean score on the performance task for all groups was (M=2.8).

There was no variance between the means score of the three groups on the math

performance task.

Table 15: Analysis of the Variance (ANOVA)

		Sum of Squares	df	Mean Square	F	Sig.
Test Anxiety Scale	Between Groups	775.988	2	387.994	3.288	.041*
	Within Groups	14750.012	125	118.000		
	Total	15526.00	127			
Math Anxiety Scale	Between Groups	205.740	2	102.870	.840	.434
	Within Groups	15668.764	128	122.412		
	Total	15874.504	130			
Performance Task	Between Groups	.011	2	.006	.003	.997
	Within Groups	254.936	128	1.992		
	Total	254.947	130			

*Correlation significant at the .05 level of significance

An ANOVA was performed to examine the differences between the experimental

groups on the math performance test; and to test the null hypotheses. The results yielded

a significant effect for test anxiety $F_{(2,125)} = 3.288$, $p < .041$. In this case, there is only a

4.1% chance that the F-ratio could have occurred by chance. Therefore, the null

hypothesis is rejected. There is a relationship between the experimental groups on test

anxiety.

Table 16: Tukey Post Hoc Analysis Tests

Variable	(I) Groups	(J) Groups	Mean Diff. (I-J)	Std. Error	Sig.	95% CI Lower	95% CI Upper
Math Anxiety Scale	Math Anxiety	Test Anxiety	3.05814	2.37253	.404	-2.5678	8.6841
		Stereotype Threat	1.79545	2.35885	.727	-3.7981	7.3890
	Test Anxiety	Math Anxiety	-3.05814	2.37253	.404	-8.6841	2.5678
		Stereotype Threat	-1.26268	2.37253	.856	-6.8886	4.3633
	Stereotype Threat	Math Anxiety	-1.79545	2.35885	.727	-7.3890	3.7981
		Test Anxiety	1.26268	2.37253	.856	-4.3633	6.8886
Test Anxiety Scale	Math Anxiety	Test Anxiety	4.86197	2.35794	.102	-.7310	10.4549
		Stereotype Threat	5.44450	2.32938	.054*	-.0807	10.9697
	Test Anxiety	Math Anxiety	-4.86197	2.35794	.102	-10.454	.7310
		Stereotype Threat	.58253	2.38113	.967	-6.2067	6.2067
	Stereotype Threat	Math Anxiety	-5.44450	2.32938	.054*	-10.969	.0807
		Test Anxiety	.58253	2.37113	.967	-6.2067	5.0417
Performance Task	Math Anxiety	Test Anxiety	-.01956	.30263	.998	-.7372	.6981
		Stereotype Threat	.00000	.30088	1.00	-.7135	.7135
	Test Anxiety	Math Anxiety	.01956	.30263	.998	-.6981	.7372
		Stereotype Threat	.01956	.30263	.998	-.6981	.7372
	Stereotype Threat	Math Anxiety	.00000	.30068	1.00	-.7135	.7135
		Test Anxiety	-.01956	.30263	.998	-7372	.6981

*Correlation significant at the .05 level of significance

Following the ANOVA, a post hoc analysis was conducted at the .05 significance

level. The purpose of the post hoc analysis is to test which pairs of means differ

significantly. The post hoc test used for this analysis is Tukey's Honestly Significant Difference (HSD) Test.

The results of the post hoc analysis yielded a significant mean difference between one pair, specifically groups math anxiety (M= 41.71) and stereotype threat (M= 36.44), on the test anxiety scale. In sum, the results of the Tukey test suggest that participants in the control group and the stereotype threat experimental group were significantly different on the test anxiety scale. There were no differences on the MARS-R between the groups.

Table 17 summarizes the group statistics for the variables by gender and Table 18 summarizes the t-test analysis for the variables in the study and gender.

Table 17: Group Statistics on the Variables and Gender

	Gender	*N*	Mean	Std. Deviation	Std. Error Mean
Math Anxiety Scale	Females	108	33.0741	10.86855	1.04583
	Males	24	26.0000	10.30829	2.10417
Test Anxiety Scale	Females	108	39.0849	10.56690	1.02635
	Males	24	35.6087	12.78045	2.66491
Performance Task	Females	108	2.8426	1.42843	.13745
	Males	24	2.9583	1.33447	.27240

Table 18: T-Test on the Variables and Gender

Groups	Levene Test for Equality of Variance		T-test for Equality of Mean					95% Confidence Interval	
	F	Sig.	t	df	Sig.	Mean Diff.	Std. Error of Diff.	Lower	Upper
Gender	.246	.621	.274	129	.785	.05101	.18649	-.31797	.41999
Math Anxiety Scale	.421	.518	-2.910	130	.004*	7.07407	2.43079	-11.88310	-2.2650
Test Anxiety Scale	2.489	.117	-1.376	127	.171	-3.4762	2.52623	-8.47517	1.52275
Math Task	.893	.346	.363	130	.717	.11574	.31870	-.51477	.74625

*Correlation significant at the .05 level of significance

Between males and females the only scale yielding a significant difference on the

t-test was the MARS-R. Student responses on the MARS-R ranged from 10 to 50, for

females the (M=33.07, SD= 10.86) and for males (M=26.00, SD= 10.30). The data

yielded a *t* (-2.910) with df (130) and a p value of .004. This *t* value also falls outside the

95% confidence interval. This finding suggests that a significant relationship exists

between gender and scores on the Math Anxiety Rating Scale-Revised. Females scored

significantly higher on the math anxiety scale.

Summary of the Data Analysis

The data summary discusses the descriptive statistics and inferential statistics.

First, the data summary will report the data analysis for the attitude items, followed by

the data analysis for the scales and the performance task and finally, the results of the

ANOVA and the post hoc analysis.

Of the two Pearson correlations between the math performance and the two anxiety scales were significant. The data yielded two negative correlations between math anxiety and performance of -.320 (p< .01); and test anxiety and performance of -.170 (p< .05). That is, as anxiety increased, the scores on the performance task would decrease. The results suggest that, while weak, there is a relationship between mathematics anxiety and performance and test anxiety and performance in pre-service teachers. In addition, the correlation between the MARS-R and TAI was significant at the .05 level of significance. The data yielded a positive correlation between the MARS-R and the TAI of .432 (p< .05). The r^2 indicates that 18% of the variance is shared between the MARS-R and the TAI.

A t-test was conducted to analyze the relationship between gender and self-reported math anxiety. The results yielded a significant relationship between gender and the attitude item "a high level of math anxiety best describes me". That is, the results suggest that, females in this study had a significantly higher level of self-reported math anxiety than males. Therefore, the null hypothesis that there is no relationship between females and males and their self-reported level of math anxiety is rejected.

In addition, t-tests were conducted to analyze the relationship between gender and the scales (MARS-R and TAI); and gender and performance in the stereotype threat experimental group. The results yielded a significant relationship between gender and scores on the MARS-R. Therefore, the null hypothesis that there is no relationship between gender and scores on the Mathematics Anxiety Rating Scale-Revised is rejected. The results also yielded a significant relationship between females and males in the

stereotype threat group and math performance. Therefore, the null hypothesis that there is no relationship between gender and scores on the math performance task is rejected.

On the Test Anxiety Inventory (TAI), the majority of females surveyed scored between 30 and 60 on the TAI, while the majority of males surveyed scored between 20 and 40. These scores indicated that female participants also had a higher level of test anxiety. Chi square tests were performed to examine the relationship between females and males. Of the chi square measures performed, the results yielded a significant relationship between females and males and the MARS-R; and between females and males and the TAI.

There were no significant differences between the mean score of the math anxiety group, the test threat group and the stereotype threat group on the performance task. The mean score for all three groups was (M=2.8). This suggests that participant knowledge was equal across the random groups, which further suggests that the experimental treatments lead to differences in performance not knowledge.

Finally, the data results from the ANOVA yielded a significant effect for test anxiety at the .05 level of significance. Therefore, the null hypothesis is rejected. There is a significant difference between the math anxiety, stereotype, and test anxiety groups. The results of the post hoc analysis yielded a significant difference between groups 1 and 3 on the test anxiety scale. In sum, the post hoc analysis found that the control (math anxiety) group and the stereotype threat were significantly different from each other.

The researcher drew several conclusions from the present study. First, the correlational data yielded a negative correlation, that is, as anxiety increased, performance decreased. Second, there was no mean score difference between the math

anxiety group, the test threat group and the stereotype threat group on the performance

task. This suggests that the experimental treatments not knowledge accounted for the

difference in performance. Third, the comparison of the means t-test calculated

significant relationships between females and scores on the MARS-R, between females

and their self-reported mathematics anxiety; and between females and males in the

stereotype threat group on performance. Lastly, there is a relationship between the Test

Anxiety Inventory (TAI) and the experimental groups. Moreover, one pair of means (the

control group and the stereotype threat group) differed significantly on the test anxiety

scale. That is, the participants in group 1 and group 3 (math anxiety group and stereotype

threat group) scored higher on the test anxiety scale than participants in group 2 (test

threat group). This suggests that the experimental instructions given to the stereotype

threat increased anxiety.

CHAPTER 5

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

This chapter is organized around the data and results reported in Chapter 4. The discussions and conclusions are based on the research questions presented in Chapter 1. In the subsequent sections of the paper the implications of the study are discussed, suggestions are made for further research, and finally, recommendations for teacher education programs to reduce mathematics anxiety in pre-service teachers are offered.

Discussion of Research Findings

The results of this study add to the current literature on anxiety in two ways. First, it is clear that in spite of consistent levels of mathematics performance, pre-service teachers continue to exhibit high levels of anxiety. The pre-service teachers, especially female pre-service teachers, were math anxious regardless of their level of mathematics performance. Secondly, the experiment compared three different randomly assigned groups: math anxiety, test anxiety, and stereotype threat on three dependent variables: the TAI, MARS-R, and Math Performance. There were significant differences between the experimental groups on the TAI and between gender and performance in the third experimental group (stereotype threat). The means test showed significant differences between the math anxiety and the stereotype threat group. Correlational data revealed a significant inverse relationship between the two scales and performance on the math task. That is, as anxiety increased, scores on the performance task decreased. The correlational data also yielded a positive linear relationship between the MARS-R and the TAI.

With respect to mathematics performance, there were no significant differences between the three groups, that is, the control group (math anxiety group), the test anxiety

group and the stereotype threat group. This is an important finding. A reasonable explanation for the lack of significant differences between the three groups with respect to performance supports the procedure of random assignment of the groups. That is, since participants were evenly distributed throughout the experimental condition, it can be assumed that the levels of anxiety were equally distributed between the three experimental groups.

However, the groups did perform differently on the Test Anxiety Inventory (TAI). The scores obtained from the Mathematics Anxiety Rating Scale-Revised (MARS-R) did not differ across the three different conditions. This suggests that the TAI discerned differences that the MARS-R did not. The data showed a significant difference between the math anxiety group and the stereotype threat group on the TAI. Given the literature reviewed on stereotype threat, it is reasonable for the researcher to conclude that the participants in the stereotype threat group, the majority of who were female, scored higher on the TAI for two reasons. First, the participants were placed in an evaluative situation (i.e. testing situation). Secondly, the participants were involved in a situation that may have confirmed a negative stereotype about one's group (i.e. females and poor math performance). Finally, according to the literature the two reasons previously discussed diminish academic achievement because they interfere with performance (Hendel, 1980; Steele, 1997; Spencer et al, 1999; Aronson et al, 1999).

These conclusions obtained from the literature were consistent with the questionnaire results for female participants in the current study. For example, over half of the female participants in this study reported that mathematics was their least favorite subject. Results also revealed that females had a significantly higher self- reported level

of math anxiety than the male participants in the study. Not only did females report a high level of math anxiety on the attitude questionnaire, they also had a significantly higher score on the MARS-R (i.e. a scale that measures mathematics anxiety in college students).

The secondary purpose of this study was to examine the relationship between math anxiety, test anxiety, and stereotype threat in pre-service teachers. It was predicted that the comparison of the experimental conditions (i.e. test threat and stereotype threat) would reveal no significant differences between the groups on performance. This hypothesis was confirmed in the main. Only one significant difference emerged from the data. There was a significant difference between the math anxiety group and the stereotype threat group on the TAI.

Some important findings of the study was the significant difference between the control group (i.e. the math anxiety group) and the stereotype threat experimental group on the Test Anxiety Inventory on the Tukey HSD Test and females in the stereotype threat group having a significantly lower score on the performance task than male participants in the stereotype threat group. Recall that, the stereotype threat group was informed that they were taking a test and that their scores would be compared to male students. In contrast, the control group received no such instructions. It is reasonable to conclude that the combination of a test focusing on anxiety and being told in the stereotype condition that they were to take a test and be compared to other university students who are thought to be more proficient produced significant differences in performance

Conclusions

The primary purpose of this research study was to explore mathematics anxiety in pre-service teachers. This study posed the question of whether or not a relationship exists between mathematics anxiety and performance among pre-service teachers. Consequently, the study examined the relationship between forms of anxiety (i.e. mathematics and tests) and stereotype threat on the math performance of pre-service teachers.

This research study originated with the question "*Is it really math anxiety*?" This study shows that the mathematics knowledge of participants did not differ between the experimental conditions. This indicates that the randomization procedures were effective and that math anxiety not knowledge contributed to differences. There were three experimental conditions: mathematics anxiety (control), test anxiety, and stereotype threat, and two measures of anxiety: the Test Anxiety Inventory and the Mathematics Anxiety Rating Scale-Revised. The only significant difference between the experimental conditions and measures of anxiety was the significant difference between the mathematics anxiety condition and the stereotype threat condition on the Test Anxiety Inventory (TAI). This suggests that stereotype threat is a potent variable that must be considered in understanding anxieties of pre-service teachers.

The findings of the current study suggest that a high level of mathematics anxiety also has its roots in negative societal stereotypes. This finding is supported by the literature on stereotype threat. Steele (1995, 1997) and his colleagues (Aronson et al., 1998; Spencer et al., 1999; Brown & Josephs, 1999; Schmader, 2002; Schmader et al.,

2004) argue that negative societal stereotypes are situational threats that impact performance when an individual worries about confirming negative stereotypes.

The consequences of negative experiences and negative stereotypes are serious and have serious implications. The consequences discussed in the literature are academic barriers (Steele, 1997; Aronson et al., 1998), career limitations (Sells, 1972; Mantey, 2007), avoidance of mathematics (Elliott, 1983; Kelly and Tomhave, 1985) and "internalized anxiety" (Steele and Aronson, 1995).

Implications

In 2000, the National Council of Teachers of Mathematics (NCTM) presented *Principles and Standards for School* Mathematics to the educational community. This document set forth an ambitious vision for mathematics education that encompasses the goal of excellence for all students. In doing so, they argued that teachers are the primary agents for change. Charlesworth (1997) suggests that while some change will come through in-service teacher programs, much of the change will emanate from new teachers. Similarly, Trujillo and Hadfield (1999) offered the following "In looking for solutions and potential interventions, a thorough investigation of teachers' and preservice teachers' perceived causes of their own mathematics anxiety could help to build a theory as to future prevention. Also, through exploration of their own backgrounds, preservice teachers may perhaps identify and confront their own personal levels of mathematics anxiety prior to entering the classroom as teachers." (p.219). Therefore, as educators prepare students to function in the technological twenty-first century, we must examine mathematics anxiety specifically as it relates to pre-service teachers and the influences of teacher mathematics anxiety in the elementary school classroom.

These findings indicate, the future teachers in this study, came to their collegiate program with a high level of mathematics anxiety, a negative attitude toward mathematics and a negative attitude toward teaching mathematics. These students have been and will continue to be influenced by their experiences during their collegiate program. The literature suggests that the experiences of the pre-service teachers can have a powerful and lasting impact on their anxieties about mathematics and teaching mathematics. Moreover, their anxieties and attitudes will have just as powerful an impact on the culture of mathematics in future classrooms of their own. Perry (2004) suggests that the blame for poor mathematics instruction in elementary schools ultimately lie with teachers, and in turn, some of the blame lies with schools of education at colleges and universities. The study also indicates that stereotypes and stereotype threat are issues that should be addressed in the education of pre-service students.

Changes in the way mathematics will be taught in elementary schools by future teachers require changes in their preparation in teacher education programs. NCTM (1989) called for the development of mathematical power for all students. Mathematical power includes the ability to explore, to conjecture and to reason logically; to solve non-routine problems; to communicate about mathematics and through mathematics; and to connect ideas within and between mathematics and other disciplines.

If future teachers are to produce mathematical literacy in their students, they must develop an understanding of the conceptual framework of mathematics anxiety as it relates to teaching mathematics. Teacher education programs must not only prepare pre-service teachers to develop a mathematics curriculum, which stimulates mathematical ideas and mathematical confidence, but must also acknowledge and address math

anxiety, math attitudes, societal stereotypes and examine ways to attitudes towards

mathematics, improve the teaching of mathematics, foster the development of

mathematical literacy and therefore, decrease "math anxiety".

It seems reasonable that teachers who enter the classroom with a low level anxiety

towards mathematics along with knowledge of mathematics (content) and pedagogical

content knowledge (i.e. the teaching of mathematics) are more likely to implement

effective mathematics instruction in the classroom. This creates a positive mathematics

culture in the classroom thus helping to promote positive attitudes about mathematics and

mathematics achievement for students. Effective and engaging mathematics instruction

must begin in the elementary school classroom if we are to reduce mathematics anxiety in

students. Therefore, teacher education programs are obligated to find ways to reduce

math anxiety in pre-service teachers, and ultimately future generations of students.

Limitations

Based on the findings and conclusions of this study, the following limitations

should be considered. One, only a small number of males participated in the study. The

small number of males limits the male perspective and therefore the generalizability of

the study. Another limitation of the study is that there were not a large number of

African-American students in the study. It is therefore not possible to generalize the

findings of this study to that population; nevertheless, the literature on stereotype threat

suggests that performance and stereotype threat are relevant to African-Americans and

females who suffer the greater effects of negative stereotypes. Thus, one final limitation

is the fact that race was not controlled for as a factor in this research study.

Future Research

Future research in the area of mathematics anxiety and pre-service teachers might consider the following suggestions. First, future research might benefit by using the Mathematics Anxiety Rating Scale-Revised (MARS-R) as a covariate. That is, as a pre-test rather than a post-test to further deconstruct mathematics anxiety and test anxiety. Second, future research might benefit from including more males and African-Americans to provide greater diversity and more generalizability to those populations. Third, future research might benefit by including students from other majors in colleges and universities throughout the country. The third suggestion would provide researchers with other groups for the purposes of comparison. This might provide more insight into mathematics anxiety in college students with particular focus on comparing education majors to students in other areas of study and provide results that can be generalized. Future research might benefit by studying these same variables in individual conditions to obtain qualitative data on the experiences of students with math anxiety. Finally, future research might benefit by including a performance task with a greater number of questions and more difficult questions in an attempt to further examine mathematics knowledge and its impact on mathematics anxiety because increasing the range of the variables also increases the size of the correlations.

Recommendations

It is the opinion of this researcher that additional support should be provided for pre-service teachers especially those pre-service teachers who are math anxious. Approximately eight years ago, in an attempt to provide support to prospective teachers, the National Science Teachers Association (NSTA) established student chapters on

college campuses to encourage educators-in-training to share ideas and concerns that will help them as they enter the profession. Collegiate NSTA chapters are now located on over one hundred campuses nationwide (Cavanagh, 2008). Collegiate chapters of NCTM sponsored by the Colleges of Education could provide support for pre-service teachers.

Another support, and probably the most practical solution, is to provide students with a mathematics methods course that reduces mathematics anxiety through the development of mathematical content, methodology and pedagogy. Specifically, the literature suggests that this can be accomplished in one of four ways.

First, through the use of non-traditional approaches (i.e. manipulatives, open discussion, emphasis on understanding, "real-world mathematics", etc.) in the mathematics methods courses can reduce mathematics anxiety (Sovchik et al., 1981; Battista, 1986; Taylor and Brooks, 1986; Schneider, 1988; Hembree, 1990; Thompson, 1992; Emenaker, 1996; Seymour, 1996; Vinson et al., 1997; Harper & Daane, 1998; Tobias, 1998; Tooke & Lindstrom, 1998; Trujillo & Hadfield, 1999; Vinson, 2001). Second, methodology courses that address the affective issues (i.e. anxiety, attitude) are the most effective courses (Reyes, 1984; Trujillo & Hadfield, 1999). Next, courses that refute stereotypes are an effective technique (Walsh, 1999). Finally, instruction methods presented in a mathematics methods course are a powerful source in shaping attitudes and confidence thus reducing mathematics anxiety (Sovchik et al.,1981; Stodolsky,1985; Lindquist & Elliott, 1996; Harper & Daane, 1998; Vinson, 2001; Bursal & Paznokas, 2006).

In addition to the support strategies discussed specifically for teacher education programs, support strategies for minimizing anxiety and improving attitudes toward

mathematics should be a campus-wide effort. In recent years, while controversial, a popular strategy that has been experimented with, and implemented across the country, is to separate males and females for math classes. For example, Iossi (2007) suggested single-sex math courses as a strategy for minimizing math anxiety. Campbell and Evans (1997) found that females in single-sex classrooms experienced a lowering of math anxiety (as measured by the MARS-A test) as compared to a slight gain in anxiety noted in females from coeducational classrooms. Although single sex class math courses are still being debated, researchers and educators alike agree that we are faced with the question of ways to decrease math anxiety and raise math confidence for all students, especially females.

Another form of support can be provided through math support groups, workshops, seminars and courses. The purposes of a math anxiety course or a math support group include overcoming math anxiety, recognizing fears and misconceptions about mathematics, exploring the connection between anxiety and a students ability to perform mathematics, identifying techniques and strategies to help one overcome mathematics anxiety and other barriers impeding mathematics success. Colleges that have implemented math anxiety courses are Butte College, American River College and Chabot College (Iossi, 2007). A math support group, The Math Confidence Group at the University of Florida, has met once a week for nearly twenty years to provide support for math anxious students (Iossi, 2007).

In conclusion, student support strategies may be beneficial in decreasing math anxiety and improving subsequent success throughout the collegiate and professional years. Finally, it is my hope that this research study contributes to the larger literature on

mathematics anxiety among pre-service teachers and encourages teacher education

programs to be more responsive to the mathematics anxiety of prospective teachers.

APPENDICES

APPENDIX A

Cosent Form

Dear Study Participant,

My name is Marsha M. Guillory Bryant and I am a Doctor of Education candidate at the University of Massachusetts Amherst. I am inviting you to participate in a research project to study mathematics anxiety in pre-service teachers. To collect the information for this study, three Likert scales and a performance tasks will be completed. The scales and the questionnaire should take you about twenty minutes to complete. The performance task should take approximately thirty minutes to complete.

In order to participate in the study, first, you must sign the consent form; then you will complete the scales and the performance task. There are no risks to you or to your privacy if you decide to participate in this study. The confidentiality of participants will be maintained. Moreover, individual responses will not be reported, therefore there is no risk of an individual respondent being identified and made vulnerable by his or her responses to the surveys.

Your responses will not be made available to any of your faculty members. However, the data will be discussed with the investigator's University of Massachusetts Amherst faculty dissertation committee members and presented in a doctoral dissertation. In addition, the results may be used in future publications.

I hope you will take the time to participate in this study. Your participation is voluntary and there is no penalty if you do not participate. You may withdraw from the study at any time for any reason and you have the right to review your materials.

Thank you for your time and I greatly appreciate your participation. If you have any questions about the research study or being a participant in this study, please contact me at mmbryant@educ.umass.edu. My faculty advisor and principal investigator, Dr. Ernest Washington, may be contacted at ewashington@educ.umass.edu.

Sincerely,

Marsha M. Guillory Bryant

Name: _____ Random Number: _____

Email Address: _____

_____   I understand the above statements and agree to participate in this study.
(Please mark)

Personal Data Questionnaire

Name: _____   Random Number: _____

Personal Data Questionnaire

1. What is your age? _____

2. What is your gender?   Female   Male

3. What is your race/ethnic group?
Caucasian   African-American/Black   Native American   Pacific Islander

Hispanic/Latino   Asian American   Other (please specify)_____

4. Circle the highest level of mathematics you studied in school?

Grade 10   Grade 11   Grade 12

College
_____
_____
_____
_____
(Please specify college course(s) title and course number(s))

5. Math is my least favorite subject in school?
   Strongly agree   Agree   Disagree   Strongly disagree

6. Math is my least favorite subject to teach in the classroom?
   Strongly agree   Agree   Disagree   Strongly disagree

7. A high level of mathematics anxiety best describes me?
   Strongly agree   Agree   Disagree   Strongly disagree

8. Briefly describe your personal experiences as a student in the mathematics classroom?

_____
_____
_____
_____

9. How do you think these experiences have affected you and your mathematics instruction in the classroom?

_____
_____
_____
_____
_____
_____

10. Did you complete the Mathematics Methods Course? Yes   No

If you responded "yes" to question 10: Please answer questions 11, 12, 13 and 14. If no, proceed to question 15.

11. When did you take the Mathematics Method Course (semester and year)?

12. Did the course decrease your mathematics anxiety?   Yes   No
If yes, list the **one** factor that most contributed to a decreased level of anxiety. If no, why not?
_____
_____
_____

13. Did the course improve your attitude toward mathematics?   Yes   No
If yes, list the **one** factor that most contributed to the improvement in your attitude. If no, why not?
_____
_____
_____

14. Did the course improve your attitude towards teaching mathematics in the elementary school classroom?   Yes   No
If yes, list the **one** factor that most contributed to the improvement in your attitude towards teaching mathematics in the elementary school classroom. If no, why not?
_____
_____
_____

15. A high level of test anxiety best describes me.
Strongly agree   Agree   Disagree   Strongly disagree

16. If you answered strongly agree or agree on question 15, list the **one** factor that most contributed to your test anxiety.
_____
_____

Mathematics Anxiety Rating Scale

Mathematics Anxiety Rating Scale

The following are mathematics anxiety statements, about which your opinion is sought. For each statement, please circle the response that most closely indicates your extent of agreement or disagreement with the statement.

1. It doesn't bother me at all to take more math classes.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

2. I have usually been at ease during math tests.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

3. I have usually been at ease during math courses.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

4. I usually don't worry about my ability to solve math problems.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

5. I almost never get uptight during math tests.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

6. I get really uptight during math tests.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

7. I get a sinking feeling when I think of trying hard math problems.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

8. My mind goes blank and I am unable to think clearly when working mathematics.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

9. Mathematics makes me feel nervous and uncomfortable.

    Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

10. Mathematics makes me feel uneasy and confused.

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

This Likert scale survey is based on a survey developed by E. Fennema and J. Sherman (1976) found in: Betz, N. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25* (5), 441-448.

Test Anxiety Inventory

Test Anxiety Inventory

The following are test anxiety statements about which your opinion is sought. For each statement, please circle the response that most closely indicates your extent of agreement or disagreement with the statement.

1. I feel confident and relaxed while taking tests.
Almost Never   Sometimes   Often   Almost Always

2. While taking final examinations I have an uneasy upset feeling.
Almost Never   Sometimes   Often   Almost Always

3. Thinking about the grade I may get in a course interferes with my work on tests.
Almost Never   Sometimes   Often   Almost Always

4. I freeze up on final exams.
Almost Never   Sometimes   Often   Almost Always

5. During exams I find myself wondering whether I will ever get through school.
Almost Never   Sometimes   Often   Almost Always

6. The harder I work at taking a test, the more confused I get.
Almost Never   Sometimes   Often   Almost Always

7. Thoughts of doing poorly interfere with my concentration on tests.
Almost Never   Sometimes   Often   Almost Always

8. I feel very jittery when taking an important test.
Almost Never   Sometimes   Often   Almost Always

9. Even when I am well prepared for a test, I feel very anxious about it.
Almost Never   Sometimes   Often   Almost Always

10. I start feeling very uneasy just before getting a test paper back.
Almost Never   Sometimes   Often   Almost Always

11. During tests I feel very tense.
Almost Never   Sometimes   Often   Almost Always

12. I wish examinations did not bother me so much.
Almost Never   Sometimes   Often   Almost Always

13. During important examines I am so tense that my stomach gets upset.
Almost Never   Sometimes   Often   Almost Always

14. I seem to defeat myself while working on important test.
Almost Never   Sometimes   Often   Almost Always

15. I feel very panicky when I take an important test.
Almost Never   Sometimes   Often   Almost Always

16. If I were to take an important exam, I would worry a great deal about taking it.
Almost Never   Sometimes   Often   Almost Always

17. During tests I find myself thinking about the consequences of failing.
Almost Never   Sometimes   Often   Almost Always

18. I feel my heart beating very fast during important tests.
Almost Never   Sometimes   Often   Almost Always

19. As soon as an exam is over I try to stop worrying about it, but I just cannot.
Almost Never   Sometimes   Often   Almost Always

20. During a course examination I get so nervous that I forget facts I really know.
Almost Never   Sometimes   Often   Almost Always

This inventory was developed by Charles Spielberger (1980).

Mathematics Performance Task

Use the problem below to answer the question that follows.

> *Problem*
>
> Find $\dfrac{2}{x} + \dfrac{5}{3}$
>
> *Solution*
>
> Step 1: $\dfrac{2}{x} \times \dfrac{3}{3} + \dfrac{5}{3} \times \dfrac{x}{x}$

Step 1 above is justified mathematically by which of the following statements?

A. Applying number properties to an expression does not change its value.

B. Multiplying an expression by one does not change its value.

C. Performing the same operation on each term of an expression does not change its value.

D. Carrying out both multiplication and addition in an expression does not change its value.

Use the table below to answer the question that follows.

x	y
-2	8
0	4
2	0

Which of the following equations represents the relation above?

A. $y = -2x + 4$

B. $y = -2x - 4$

C. $y = 2x + 4$

D. $y = 2x - 4$

Two flagpoles of different heights are located in front of a school. At 5 P.M. on a given day, the 12-meter-high flagpole casts a 20-meter-long shadow and the other flagpole casts a 15-meter-long shadow. What is the height of the second flagpole?

A.   7 meters

B.   9 meters

C.   16 meters

D.   25 meters

A child has a set of blocks, of which three are square, five are round, and six are triangular. If he picks a round block from the set and gives it to his sister, what is the probability that the second block that he picks at random will also be round?
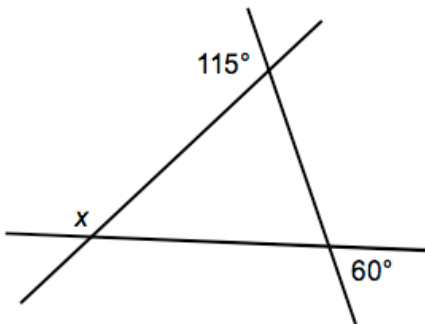
A. $\dfrac{1}{14}$

B. $\dfrac{1}{13}$

C. $\dfrac{4}{14}$

D. $\dfrac{4}{13}$

Use the diagram below to answer the question that follows.

Three straight lines intersect to form a triangle, as shown above. What is the measure of angle x?

A.   115°

B.   120°

C.   125°

D.   130°

BIBLIOGRAPHY

Aiken, L. (1972). Research on attitudes toward mathematics. *Arithmetic Teacher, 19*, 229-234.

Aronson, J., Lustina, M., Good, C., Keough, K., Steele, C., & Brown, J. (1999). When white men can't do math: Necessary and sufficient factors in stereotype threat. *Journal of Experimental Social Psychology, 35*, 29-46.

Aronson, J., Quinn, D., & Spencer, S. (1998). Stereotype threat and the academic underperformance of minorities and women. In J. Swim, & C. Stangor (Eds.), *Prejudice: The target's perspective.* (pp. 85-103). San Diego, CA.: Academic Press.

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

Atweh, B., Bleicher, R., & & Cooper, T. (1998). The construction of social context of mathematics classrooms: A sociolinguist analysis. *Journal for Research in Mathematics Education, 29*(1), 63-82.

Ball, D. (1990). Breaking with experiences in learning to teach mathematics: The role of a preservice methods course. *For the Learning Mathematics, 10*(2), 10-16.

Ball, S. (1995). Anxiety and test performance. In C. Spielberger, & P. Vagg (Eds.), *Test anxiety: Theory, assessment and treatment* (pp. 107-116). Washington, D.C.: Taylor & Francis.

Bass, A. (2007, November 1). Male elementary-education majors say they are needed minority. *Orlando Sentinel.*

Battista, M. (1986). The relationship of mathematics anxiety and mathematical knowledge to the learning of mathematical pedagogy by preservice elementary teachers. *School Science and Mathematics, 86*, 10-19.

Battista, M. (1999). The mathematical miseducation of America's youth: Ignoring research and scientific study in education. *Phi Delta Kappan, 80*, 425-433.

Becker, J. (1986). Mathematics attitudes of elementary education majors. *Arithmetic Teachers, 33*(5), 50-51.

Bessant, K. (1995). Factors associated with types of mathematics anxiety in college students. *Journal for Research in Mathematics Education, 26*(4), 327-345.

Betz, N. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25*(5), 441-448.

Brown, R., & Josephs, R. (1999). A burden of proof: Stereotype relevance and gender differences in math performance. *Journal of Personality and Social Psychology, 76*(2), 246-257.

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

Buhlman, B., & Young, D. (1982). On the transmission of mathematics anxiety. *Arithmetic Teacher, 30*(3), 55-56.

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

Bursal, M. & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-179.

Burton, G. (1979). Getting comfortable with mathematics. *The Elementary School Journal, 79*(3), 129-135.

Bush, W. (1989). Mathematics anxiety in upper elementary school teachers. *School Science and Mathematics, 89*, 499-509.

Campbell, K., & Evans, C. (1997). Gender issues in the classroom: A comparison of mathematics anxiety. *Education, 117*(3), 332-338.

Cavanagh, S. (2008). Math group tries to help young teachers stay the course. *Education Week, 27*(36), 6-7.

Charlesworth, R. (1997). Mathematics in the developmentally appropriate integrated curriculum. In C. Hart, & Burts, D. & Charlesworth, R. (Eds.), *Intergrated curriculum and developmentally appropriate practice: Birth to age eight* (pp. 51-73). Albany, NY: State University of New York Press.

Chavez, A. & Widmer, C. C. (1982). Math anxiety: Elementary teachers speak for themselves. *Educational Leadership, 39*(5), 387-388.

Chipman, S., Krantz, D., & Silver, R. (1992). Mathematics anxiety and science careers among able college women. *Psychological Science, 3*(5), 292-295.

Cook, J. & Briggs, M. (1991). In Primm, D. & Love, E. (Ed.), *Teaching and learning school mathematics*. London: Hodder & Stoughton.

Cornell, C. (1992). "I hate math! I couldn't learn it, and I can't teach it!". *Childhood Education, 75*, 225-230.

Deffenbacher, J. (1980). Worry and emotionality in test anxiety. In I. Sarason (Ed.), *Test anxiety: Theory, research and applications.* (pp. 111-128). Hillsdale, NJ: Lawrence Erlbaum Associates.

Devlin, K. J. (2000). *The math gene : How mathematical thinking evolved and why numbers are like gossip* (1st ed.). New York, NY: Basic Books.

Dew, K., & Galassi, J. Galassi. M. (1983). Mathematics anxiety: Some basic issues. *Journal of Counseling Psychology, 30*(3), 443-446.

Dew, K., Galassi, J., & Galassi. M. (1984). Math anxiety: Relation with situational test anxiety, performance, physiological arousal, and math avoidance behavior. *Journal of Counseling Psychology, 31*(4), 580-583.

Dowker, A. (2005). *Individual difference in arithmetic: Implications for psychology, neuroscience and education*. New York, NY: Psychology Press.

Elliott, P. (1983). QUESTION: Is math anxiety a figment of the imagination? ANSWER: Never! (A neurological glimpse at mathematics anxiety). *International Journal of Mathematics Education in Science and Technology, 14*(6), 777-785.

Elliott, P. (1986). Right (or left) brain cognition, wrong metaphor for creative behavior: It is a prefrontal lobe volition that makes the (human/humane) difference in the release of creative potential. *The Journal of Creative Behavior, 20*(3), 202-214.

Emenaker, C. (1996). A problem-solving based mathematics course and elementary teachers' beliefs. *School Science and Mathematics, 96*(2), 75-84.

Eysenck, M. (1992). *Anxiety, the cognitive perspective*. Hillsdale, NJ: Lawrence Erlbaum Associates.

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

Furner, J. & Berman, B. (2005). Confidence in their ability to do mathematics: The need to erdicate math anxiety so our future students can successfully compete in a high-tech globally competitive world. *Dimensions in Mathematics, 18*(1), 28-29-31.

Geen, R. (1980). Test anxiety and cue utilization. In I. Sarason (Ed.), *Test anxiety: Theory, research and applications.* (pp. 43-61). Hill: Lawrence Erlbaum Associates.

Glass, G. & Hopkins, K. (1996). *Statistical methods in education and psychology* (3rd ed.). Needham Heights, MA: Allyn & Bacon.

Goodwin, W. & Goodwin, L. (1996). *Understanding quantitative and qualitative research in early childhood education*. New York, NY: Teachers College Press.

Greenwood, J. (1984). My anxieties about math anxiety. *Mathematics Teachers, 77*, 662-663.

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

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

Haylock, D. (2001). *Mathematics explained for primary teachers*. London: Paul Chapman Publishing.

Heikkero, T. (2008). How to address the volitional dimension of the engineer's social responsibility. *European Journal of Engineering Education., 33*(2), 161-168.

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

Hendel, D. (1980). Experiential and affective correlates of math anxiety in adult women. *Psychology of Women Quarterly, 5*(2), 219-230.

Hinkle, D., Wiersma, W., & Jurs, S. (2003). *Applied statistics for the behavioral sciences.* (5th ed.). Boston, MA: Houghton Mifflin Co.

Inzlicht, M., & Ben-Zeev, T. (2003). Do high achieving female students underperform in private? implications of threatening environments on intellectual processing. *Journal of Educational Psychology, 95*(4), 796-805.

Iossi, L. (2007). Strategies for reducing math anxiety in post-secondary students. *Proceedings of the Sixth Annual College of Education Research Conference: Urban and International Education Section,* Miami: Florida International University. 30-35.

Karp, K. (1989). Elementary school teachers' attitudes toward mathematics: Impact on students' autonomous learning skills. *American Education Research Organization,* 1-24.

Karp, K. S. (1991). Elementary school teachers' attitudes toward mathematics: The impact on students' autonomous learning skills. *School Science and Mathematics, 91*(6), 265-270.

Kazelskis, R., Reeves, C., Kersh, M., Bailey, G., Cole, K., Larmon, M., et al. (2000). Mathematics anxiety and test anxiety: Separate constructs? *Journal of Experimental Education, 68*(2), 137-146.

Keller, J. (2002). Blatant stereotype threat and women's math performance: Self-handicapping as a strategic means to cope with obtrusive negative performance expectations. *Sex Roles, 47*(3/4), 193-198.

Keller, J., & Dauenheimer, D. (2003). Stereotype threat in the classroom: Dejection mediates the disrupting threat effect on women's math performance. *Personality and Social Psychology Bulletin, 29*, 371-381.

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

Kuhls, J., & Kazen-Saad, M. (1989). Volition and self-regulation: Memory mechanisms mediating the maintenance of intentions. In W. Hershberger (Ed.), *Volitional action: Conation and control* (pp. 387-407). Amsterdam: North-Holland.

Larson, C. (1983). Techniques for developing positive attitudes in preservice teachers. *Arithmetic Teacher, 31*(2), 8-9.

Lazarus, M. (1974). Mathophobia: Some personal speculations. *National Elementary Principal, 53*(2), 16-22.

Levitt, E. (1980). *The psychology of anxiety*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Liebert, R., & Morris, L. (1967). Cognitive and emotional components of test anxiety: A distinction and some initial data. *Psychological Reports, 20*, 975-978.

Lindquist, M., & Elliott, P. (1996). Communication-an imperative for change: A conversation with Mary Lindquist. In P. Elliott, & M. Kenney (Eds.), *1996 yearbook: Communication in mathematics K-12 and beyond* (pp. 1-11). Reston, VA: The National Council of Teachers of Mathematics, Inc.

Madsen, A. (1992). Preparing elementary teacher candidates to teach mathematics nontraditionally. *Teacher Education and Practice, 82*(1), 75-100.

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

Mandler, G., & Sarason, I. (1952). A study of anxiety and learning. *Journal of Abnormal and Social Psychology, 47*, 166-173.

Mantey, J. (2007, June 21). College majors could cause women to earn less. *U.S. News and World Report*.

Marklein, M. B. (2005, October 19). College gender gap widens: 57% are women. *U.S. Today*.

Martinez, J. (1987). Preventing math anxiety: A prescription. *Academic Therapy, 23*, 117-125.

Massachusetts Department of Education and National Evaluation Systems, Inc. (2006). *Massachusetts tests for educator licensure.* Retrieved March 31, 2008, from http://www.mtel.nesinc.com/

Mather, M., & Adams, D. (2008). *The crossover in female-male college enrollment rates.* Retrieved August 15, 2008, from http://www.prb.org.silk.library.umass.edu:2048/Articles/2007/CrossoverinFemaleMaleCollegeEnrollmentRates.aspx

May, R. (1977). *The meaning of anxiety*. New York, NY: Norton.

McAuliffe, E., & Trueblood, C. (1986). Factor analysis: A tool for studying mathematics anxiety. *The 70th Annual Meeting of the American Educational Research Association.* San Francisco, CA.

McDevitt, T., Heikkinen, H., Alcorn, J., & Ambrosio A. & Gardner, A. (1993). Evaluation of the preparation of teachers in science and mathematics: Assessment of preservice teachers' attitudes and beliefs. *Science Education, 77*(6), 593-610.

McKeachie, W. (1995). Foreward. In C. Spielberger, & P. Vagg (Eds.), *Test anxiety: Theory, assessment and treatment* (pp. xi-xii). Washington, D.C.: Taylor & Francis.

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

National Education Association. (2008). *Wanted: More male teachers.*, March 24, from www.nea.org

Osborne, J. (2001). Testing stereotype threat: Does anxiety explain race and sex differences in achievement? *Contemporary Educational Psychology, 26*, 291-310.

Perry, A. (2004). Decreasing math anxiety in college students. *College Student Journal, 38*(2), 321-324.

Reyes, L. (1984). Affective variables and mathematics. *The Elementary School Journal, 84*, 558-581.

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

Richardson, F., & Woofolk, R. (1980). Mathematics anxiety. In I. Sarason (Ed.), *Test anxiety: Theory, research and applications*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Ruffell, M., Mason, J., & & Allen, B. (1998). Studying attitude to mathematics. *Educational Studies in Mathematics, 35*, 1-18.

Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology, 38*, 194-201.

Schmader, T., Johns, M., & Barquissau, M. (2004). The costs of accepting gender differences: The role of stereotype endorsement in women's experience in the math domain. *Sex Roles, 50*(11-12), 835-850.

Schneider, J. (1988). How to help your kids overcome math anxiety. *PTA Today, 14*, 14.

Sells, L. (1978). Mathematics- A critical filter. *The Science Teacher, 45*(2), 28-29.

Sepie, A., & Keeling, B. (1978). The relationship between types of anxiety and under-achievement in mathematics. *Journal of Educational Research, 72*(1), 15-19.

Seymour, D. (1986). Math is learning in action. *Learning.* , 43-47.

Sieber, J. (1980). Defining test anxiety: Problems and approaches. In I. Sarason (Ed.), *Test anxiety: Theory, research and applications* (pp. 15-40). Hillsdale, NJ: Lawrence Erlbaum Associates.

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

Smith, J., & White, P. (2002). An examination of implicitly activated, explicitly activated, and nullified stereotypes on mathematical performance: It's not just a woman's issue. *Sex Roles, 47*(3/4), 179-191.

Sovchik, R., Meconi, L. J., & & Steiner, E. (1981). Mathematics anxiety of preservice elementary mathematics methods students. *School Science and Mathematics, 81*, 643-648.

Spencer, S., Steele, C., & Quinn, D. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*, 4-28.

Spielberger, C. (Ed.). (1966). *Anxiety and behavior*. New York, NY: Academic Press.

Spielberger, C. (1980). *The test anxiety inventory*. Palo Alto, CA: Consulting Psychologists Press.

Spielberger, C., & Vagg, P. (Eds.). (1995). *Test anxiety: Theory, assessment and treatment*. Washington, D.C.: Taylor & Francis.

SPSS Incorporated. (2002). *Statistical package for the social sciences (SPSS)*.

Steele, C. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52*(6), 613-629.

Steele, C. (1998). Stereotyping and its threat are real. *American Psychologist, 53*(6), 680-681.

Steele, C. (1999, August). Thin ice: "stereotype threat" and black college students. *Atlantic Monthly,* 44-54.

Steele, C., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*(5), 797-811.

Stodolsky, S. (1985). Telling math: Origins of math aversion and anxiety. *Educational Psychologist, 20*(3), 125-133.

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

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

Tate, W. (1995). School mathematics and African-American students: Thinking seriously about opportunity-to-learn standards. *Educational Administration Quarterly, 31*(3), 424-448.

Taylor, L. & Brooks, K. (1986). Building math confidence by overcoming math anxiety. *Adult Literacy & Basic Education, 102*, 7-8.

Teague, P. T. & Austin-Martin, G.G. (1981). Effects of a mathematics methods course on prospective elementary school teachers' math attitudes, math anxiety and teaching performance. *ERIC Document,*

Thompson, A. (1992). Teachers beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook on research on mathematics teaching and learning* (pp. 127-146). New York, NY: Macmillan Publishing Co.

Tobias, S. (1978). *Overcoming math anxiety.* New York, NY: Norton.

Tobias, S. (1981). Stress in the math classroom. *Learning, 9*(6), 34-38.

Tobias, S. (1998). Anxiety and mathematics. *Harvard Educational Review, 50*, 63-70.

Tooke, D. & Lindstrom, L. (1998). Effectiveness of a mathematics methods course in reducing math anxiety of preservice elementary teachers. *School Science and Mathematics, 98*(3), 136-139.

Trochim, W., & Donnelly, J. (2007). *The research methods knowledge base* (3rd ed.). Mason, OH: Atomic Dog Publishing.

Trujillo, K., & Hadfield, O. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College Student Journal, 33*(2), 219-232.

United States Department of Labor Bureau of Labor Statistics. (2008). Retrieved March 24, 2008, from http://www.bls.gov/

Valle, A., Cabanach, R., Nunez, J., Gonzalez-Pienda, J., & Rodriguez, S. Pineiro, I. (2003). Cognitive, motivational, and volitional dimensions of learning. *Research in Higher Education., 44*(5), 557-580.

Vinson, B. (2001). A comparison of pre-service teachers mathematics anxiety before and after a methods course emphasizing manipulatives. *Early Childhood Education Journal, 29*(2), 89-94.

Vinson, B., Haynes, J., & Sloan, T. (1998). A comparison of pre-service teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *MidSouth Educational Research Association Annual Meeting,* Nashville, TN. 1-18.

Walsh, K. (1999). A better solution for both sexes. *Fresh Writing,* September 1, 2008.

Webster's II new college dictionary (2001). Boston: Houghton Mifflin Company.

Wine, J. (1971). Test anxiety and direction of attention. *Psychological Bulletin, 76*(2), 92-104.

Wood, E. (1988). Math anxiety and elementary teachers: What does research tell us? *For the Learning of Mathematics, 86*, 8-13.

Zeidner, M. (1998). *Test anxiety: The state of the art*. New York, NY: Plenum Press.

Zettle, R., & Raines, S. (2000). The relationship of trait and test anxiety with mathematics anxiety. *College Student Journal, 34*(2), 246-259.

Zhu, J. (2004). Locating volition. *Consciousness and Cognition, 13*, 302-322.