To the Graduate Council:

I am submitting herewith a dissertation written by Bobby Leon Coleman entitled "A Study of the Prevalence and Intensity of Mathematics Anxiety in College Students and Preservice Teachers at a Large Southern University." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Education.

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A STUDY OF THE PREVALENCE AND INTENSITY OF MATHEMATICS ANXIETY IN COLLEGE STUDENTS AND PRESERVICE TEACHERS AT A LARGE SOUTHERN UNIVERSITY

A Dissertation

Presented for the

Doctor of Philosophy

Degree

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Bobby Leon Coleman

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DEDICATION

To my children and grandchildren

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ABSTRACT

Mathematics anxiety has often been identified as a factor in the avoidance of mathematics, especially in females. Some researchers claim that it can be transmitted from teacher to student, that it has a debilitating effect on mathematics learning, and that it impacts on selection of college majors and careers.

This study investigated (1) the prevalence and intensity of mathematics anxiety in college students and preservice teachers, (2) the effect on mathematics anxiety of successful completion of a mathematics-related course, and (3) the relationship of mathematics anxiety with selected factors which could affect its occurrence and intensity. Data were gathered from student volunteers enrolled in mathematics, education and English courses at The University of Tennessee. The revised Mathematics Anxiety Rating Scale (RMARS) was used as a measure of mathematics anxiety and a personal survey questionnaire provided individual background data. Course grades and ACT scores were obtained administratively, with student consent.

The data were analyzed using both one-way and two-way analysis of variance procedures, *t*-tests, and correlational analyses.

The use of volunteer subjects will likely limit the generalizability of the study, but several results were achieved: (1) mathematics anxiety appeared to be related to the choice of college major, mathematics background, mathematics avoidance, mathematics achievement and mathematics performance; (2) mathematics anxiety did not appear to be related to sex differences; and (3) successful completion of a mathematics-related course did not decrease mathematics anxiety.

The following conclusions were drawn from the study: (1) the level of mathematics anxiety in college students and preservice teachers does not appear to be sex-related; (2) completion of a mathematics-related course does not appear to decrease the level of mathematics anxiety, at least not in the short term; (3) mathematics anxiety appears to be negatively related to mathematics background, mathematics achievement and mathematics performance; (4) mathematics anxiety appears to be directly related to mathematics avoidance; and (5) factors other than mathematics anxiety should be considered to explain differences in male and female enrollments in certain mathematics courses.

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CHAPTER I

INTRODUCTION

In an increasingly technological society, proficiency in mathematical skills is essential to individual success in many existing and emerging occupational fields. It seems almost incongruous in such a society that many bright and capable high school and college students perform poorly in mathematics courses and, in some cases, avoid taking mathematics courses. This avoidance of mathematics effectively limits their choice of college majors (Sells, 1978) and restricts their career options to those which require minimal mathematical skills (Betz, 1978).

Mathematics anxiety has frequently been identified as one factor in causing students to avoid mathematics. Hendel and Davis (1978) concluded that "One symptom of mathematics anxiety is mathematics avoidance" (p. 430). Tobias (1978) indicated that "math avoidance is both a cause and a result of mathematics anxiety" (p. 8). Reyes (1984) indicated mathematics anxiety could be a cause of avoiding not only mathematics courses but certain jobs, science courses, some careers and even some colleges with heavy mathematics requirements.

Lazarus (1974), in an article discussing "mathophobia" and its impact, stated:

> Especially on the large state campuses, any faculty member who advises students has known several who changed their majors primarily to avoid a mathematics requirement, giving up a prepared career to spare themselves calculus or statistics. (p. 18)

Mathematics educators and psychologists have associated mathematics anxiety with early school experiences and teacher attitudes and have indicated that negative attitudes toward mathematics may be involuntarily transmitted from teacher to student. Phillips (1973) concluded that "the teacher's attitude toward arithmetic is significantly related to both student attitude toward arithmetic and student achievement in arithmetic" (p. 507).

In summary, while mathematics anxiety is not the only cause of mathematics avoidance and poor mathematics performance, it certainly appears to be a contributing factor. Thus, the level of mathematics anxiety present in elementary teachers may be an important factor in the mathematics performance, mathematics anxiety and mathematics avoidance of students.

I. STATEMENT OF THE PURPOSE

The purpose of this study was to investigate the prevalence and intensity of mathematics anxiety among college students and preservice teachers, to determine those

factors which are related to the occurrence of mathematics anxiety in college students and preservice teachers, and to determine whether success in a mathematics or a mathematics methods course reduces mathematics anxiety.

To accomplish this purpose, data about mathematics anxiety and possible correlates were gathered from college students and preservice teachers enrolled in selected mathematics, education and English courses. These data were then analyzed using various statistical techniques which included analysis of variance, t-tests and correlational analysis.

II. RESEARCH QUESTIONS

In order to accomplish the stated purpose of the study, several specific research questions were posed:

1. How is mathematics anxiety related to choice of college major?

2. Do male and female students report different levels of mathematics anxiety?

3. How is mathematics anxiety related to
   (a) mathematics background?
   (b) mathematics achievement?
   (c) mathematics performance?
   (d) mathematics avoidance?

4. How does successful completion of a mathematics-related course affect mathematics anxiety?

III. DEFINITION OF TERMS

The following definitions are used in this study:

1. Mathematics anxiety is "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson and Suinn, 1972, p. 554) as measured by the revised version of the Mathematics Anxiety Rating Scale (RMARS).

2. Mathematics background is the number of high school and college-level mathematics courses successfully completed by the student prior to initiation of the study.

3. Mathematics achievement is the ACT mathematics subtest score recorded on the student's permanent record.

4. Mathematics performance is the grade the student received in the mathematics-related course.

5. Mathematics avoidance is the amount of time, expressed in months, which has passed since the student's last successful completion of a mathematics course.

6. The Technical Group is composed of students enrolled in a selected mathematics-related course who are majoring in engineering, mathematics, computer science or one of the natural sciences (biology, chemistry, physics).

7. The Nontechnical Group is made up of students enrolled in a selected mathematics-related course who are

not included in the Technical Group and who are not majoring in Education.

8. The Elementary Education (Undergraduate) Group is composed of students enrolled in a selected undergraduate mathematics-related course who are majoring in elementary education.

9. The Elementary Education (Graduate) Group is made up of students enrolled in a selected graduate-level mathematics-related course who are majoring in elementary education.

10. The Mathematics Education Group is composed of students enrolled in a selected mathematics-related course who are majoring in mathematics education.

11. The General Education Group is composed of students enrolled in a selected mathematics-related course who are majoring in any area of education other than elementary education or mathematics education.

12. The Control Group is composed of students enrolled in English 1020 who are not concurrently enrolled in any mathematics-related courses.

IV. METHOD

Subjects for the study were student volunteers at The University of Tennessee, Knoxville. During the Winter Quarter, 1987, data were solicited from students enrolled in the following courses:

1. Mathematics 1540, College Algebra;

2. Mathematics 1840, Single Variable Calculus;

3. Mathematics 2120, Structure of the Number System;

4. Curriculum and Instruction 3350, Teaching Elementary School Mathematics;

5. Curriculum and Instruction 3752, Teaching of Mathematics: Geometry and Analysis, Grades 7-12;

6. Curriculum and Instruction 5290, Teaching of Mathematics in the Elementary School; and

7. English 1020, English Composition.

A total of 337 subjects participated in the study, including students from four of thirteen sections of Mathematics 1540, two of fourteen sections of Mathematics 1840, two of three sections of Mathematics 2120, the only available sections of Curriculum and Instruction 3350, Curriculum and Instruction 3752 and Curriculum and Instruction 5290, and six of the 105 sections of English 1020.

Participation by the students was on a voluntary basis and it is recognized that this is likely to affect the generalizability of the results. Students who chose not to participate in the study were requested to complete a Student Information Sheet (SIS) anonymously, providing data on their age, major, sex, avoidance of mathematics and mathematics background.

Measurement of Mathematics Anxiety

Individual scores on the Revised Mathematics Anxiety Rating Scale (RMARS) were used as the measure of mathematics anxiety. This Likert-scale instrument, a 24-item version of the 98-item Mathematics Anxiety Rating Scale (MARS) developed by Richardson and Suinn, was used and evaluated by Parker and Plake (1982) as a reliable and efficient measurement of mathematics anxiety.

Measurement of Background and Experiential Factors

The investigator developed and administered a Student Information Sheet (SIS) to gather data from each subject on their avoidance of mathematics, mathematics background, sex, age and major area of study. In addition, each subject signed a consent form which granted the investigator access to the ACT mathematics subtest score on the student's permanent record and access to the grade they received in the mathematics-related course.

Procedures

During the first two weeks of the Winter Quarter, 1987, each student in the selected mathematics-related courses and the English 1020 sections was provided with a brief description of the study and was asked to volunteer to participate in the study. Students who volunteered were required to sign a consent form stating that they were at

least 18 years of age. To avoid any problems concerning parental consent, students under 18 years of age did not participate in the study.

Those students who were 18 or older and who consented to participate in the study were then required to complete the RMARS and the SIS. The elimination of students younger than 18 is recognized as a possible souce of bias and steps were taken to investigate any differences. Although most students did volunteer to participate, some did not. Those students who chose not to participate in the study were requested to complete the SIS anonymously. During the last week of that quarter, approximately eight weeks later, the RMARS was again administered to participants. (Copies of the description of the study, the consent form, the SIS and the RMARS are included in Appendix A.)

V. ASSUMPTIONS

The following assumptions were made for the purposes of this study:

1. It was assumed that selection of sections as indicated above represents a random sample of volunteers for each group, due to the random nature of computer assignment of students to classes and sections.

2. It was assumed that students were able to accurately recall the information requested and that they responded honestly to the questions on the RMARS and the

SIS.

3. As previous researchers have done (Brush, 1978; Rounds & Hendel, 1980), it was assumed that the scores obtained from the RMARS can be treated as interval data.

VI. LIMITATIONS

1. The participants in this study were not selected by a random selection process. They were, in fact, volunteers rather a true random sample. Even though testing revealed no significant differences in age, mathematics background or avoidance of mathematics between the volunteers and the nonvolunteers, this probable bias could limit the applicability of the results to populations of volunteers.

2. Participation of subjects was restricted to students who were enrolled in the mathematics and mathematics methods courses delineated above. This restriction may limit the generalizability of the conclusions to similar populations.

3. Although 337 students initially consented to participate in the study, only 125 were finally analyzed because of selection criteria used to minimize bias. These criteria are discussed in Chapter III.

VII. STATISTICAL TREATMENT OF THE DATA

To evaluate the effect of using volunteer subjects in the study, the SIS data from seventeen nonvolunteers was collected and compared with the SIS data obtained from the volunteer participants, using *t*-tests for independent samples.

To evaluate the effect of not including students under 18 years of age in the study, a one-way analysis of variance was performed on the participants, using pretest RMARS scores as the dependent variable and age as the independent variable. Post-hoc comparison of the fifteen different age groups included in the study was done using Scheffe's test.

For the participants in the study, levels of mathematics anxiety, represented by RMARS scores, were compared by sex and major, utilizing a two-way analysis of variance. When group size was too small to support a two-way analysis of variance, a one-way analysis of variance was used, disregarding sex. A result with $p < .05$ was considered significant. When significant differences were noted, post hoc comparisons of significant effects were made using Scheffe's method.

For those students enrolled in a mathematics-related course, changes in levels of mathematics anxiety were measured by the differences in pretest and posttest RMARS scores. The significance of any change was evaluated using

a *t*-test for paired samples. A result with $p < .05$ was again considered significant.

Using the pretest RMARS scores, Pearson product-moment correlation coefficients were computed for each of the groups and separately for males and females within each group. These coefficients provided a measure of the relationships between mathematics anxiety and the background and experiential factors which were investigated.

Analysis of the RMARS

The RMARS and the SIS were used to obtain data from seventeen sections of students as outlined above. Based on data provided on the SIS, the sample was divided into seven groups, according to college major. These seven groups were (a) the Control Group, (b) the Technical Group, (c)the Nontechnical Group, (d) the Elementary Education (Undergraduate) Group, (e) the Elementary Education (Graduate) Group, (f) the Mathematics Education Group, and (g) the General Education Group. Utilizing sex (male or female) and group as independent variables and mathematics anxiety (the RMARS mean score) as the dependent variable, a two-way factorial analysis of variance was designed. Because the number of males in the Elementary Education (Undergraduate) Group and the General Education Group were too small to support the two-way analysis, a 2 X 5 design was used to test the following null hypotheses:

H_o1: There are no significant differences in RMARS pretest mean scores between males and females.

H_o2: There are no significant differences in RMARS pretest mean scores between the Control Group, the Technical Group, the Nontechnical Group, the Elementary Education (Graduate) Group and the Mathematics Education Group.

H_o3: The interactions are each zero.

A one-way analysis of variance involving all seven groups and disregarding sex was then used to test the following alternative hypothesis:

H_o2a: There are no significant differences in RMARS pretest mean scores between the Control Group, the Technical Group, the Nontechnical Group, the Elementary Education (Undergraduate) Group, the Elementary Education (Graduate) Group, the Mathematics Education Group, and the General Education Group.

Changes in Levels of Mathematics Anxiety

The RMARS was administered to each participant twice, as a pretest and a posttest. A *t*-test for paired samples was then used to test the following null hypotheses:

H_o4: There are no significant differences between RMARS pretest mean scores and RMARS posttest mean

scores within any group.

H_o5: There are no significant differences between RMARS pretest mean scores and RMARS posttest mean scores for males and females within any group.

Relationship Between the RMARS Scores and the Background and Experiential Factors

RMARS pretest scores were compared with the background and experiential factors of background, achievement, performance and avoidance by calculating Pearson product-moment correlation coefficients for each of the groups. Separate comparisons were also made for males and females within each group. These comparisons tested the following null hypothesis:

H_o6: The correlation coefficients are equal to zero.

VIII. IMPORTANCE OF THE STUDY

Additional study of mathematics anxiety as it relates to college students and to preservice teachers preparing for careers in elementary and mathematics education, is worthwhile for a number of reasons. If our students are to succeed in an increasingly technological society, a sound knowledge of mathematics is a requirement. Mathematics anxiety interferes with the development of that knowledge. It has been postulated (Gough, 1954; Bulmahn and Young, 1982; Widmer and Chavez, 1982), that the presence of

mathematics anxiety in teachers is a probable cause for creating mathematics anxiety in students. Further study is required to confirm this and to identify effective means of reducing mathematics anxiety in existing and future teacher populations.

Further study of the problem could also be beneficial in reducing or minimizing mathematics anxiety in the general college population and thereby reducing the number of students who avoid mathematics-related majors.

Additional study of the prevalence of math anxiety at this university is important to determine whether recent changes in teacher certification programs and in secondary school mathematics graduation requirements have had any significant impact on college students and preservice teachers at The University of Tennessee, Knoxville.

IX. ORGANIZATION OF THE STUDY

Chapter I states the purpose of the study and lists the research questions to be investigated. It provides definitions of terms used and a general description of the methodology used in the study. It also briefly discusses the study's limitations and assumptions, describes the statistical methodology employed and discusses the importance of the study.

Chapter II is a review of the literature and research

studies germane to the definition, description and measurement of mathematics anxiety.

Chapter III provides a detailed description of the subjects, the procedures and the instruments used in the study.

Chapter IV reports the results of the statistical analysis of the data obtained in the study.

Chapter V summarizes the study and states the conclusions, based on the findings of the study.

CHAPTER II

LITERATURE REVIEW

Educators and psychologists have discussed for many years the causes and the consequences of the negative reactions some students exhibit in response to mathematics. It has been known as mathemaphobia (Gough,1954), number anxiety (Dreger and Aiken, 1957), mathophobia (Lazarus, 1974) and various other terms. Regardless of the name by which it is called, this phenomenon can have a devastating impact on those individuals who suffer from it. Tobias (1980), in her book, Overcoming Math Anxiety, says:

> The first thing people remember about failing at math is that it felt like sudden death....failure was sudden and very frightening...no matter how much the teacher reassured them, they sensed that from that moment on, as far as math was concerned, they were through. (p. 45)

Hilton (1980) considered the impact particularly severe, stating "mathophobia may be compared with the loss of one of the primary senses" (p. 175).

Sister Mary Fides Gough (1954), in one of the very early studies, indicated that mathemaphobia was a major cause of failures in mathematics classes and that mathematics avoidance was a result of this mathemaphobia. Mathematics anxiety has consistently been used to explain

mathematics avoidance and poor performance in mathematics classes. The relationship between mathematics anxiety and mathematics avoidance has been a recurring topic in the literature.

Hilton (1980) indicated that mathematics avoidance is an urgent problem now because of the importance of mathematics in an industrialized nation. Morris (1981) stated that mathematics avoidance may, in fact, cut individuals off from full participation in our society. Lazarus (1974), Tobias (1978), Reyes (1984) and Hembree (1990) have all found a direct relationship between mathematics anxiety and mathematics avoidance.

Another recurring theme in the literature has been sex differences. Tobias (1976, 1980), Hendel and Davis (1978), Donady and Tobias (1977), Stent (1977) and others have indicated that mathematics anxiety and mathematics avoidance are particularly acute problems for female students. Ernest (1976) reported that in high school and college, when mathematics became optional, far fewer women took it. Fennema and Sherman (1976) also found that many intellectually capable students, especially females, opted not to take any high school mathematics courses beyond the minimum requirements.

Sells (1978) found female mathematics avoidance so severe at the University of California, Berkeley that 92

percent of the entering high school graduates in 1972 did not have prerequisites for entering the standard freshman calculus sequence. Skiba (1990) reports that "female students' anxiety seems more intense than the males at the same age" (p. 188). Wigfield and Meece (1988) indicated that although males and females appeared equally concerned about doing well in mathematics, "girls reported experiencing more negative affective reactions to math than did boys" (p. 215).

Hendel and Davis (1978) however, reported:

> Although males initially may be reluctant to admit that they are anxious about mathematics, our experience suggests that mathematics anxiety can be just as intense for adult men as for adult women. (p. 434)

Rounds and Hendel (1980) also cautioned that "mathematics anxiety is not limited to females but is a phenomenon that is prevalent among students who are poorly prepared in mathematics" (p. 147). Greenwood (1984) concluded that "mathematics anxiety is an equal-opportunity affliction" (p. 662). Similarly, Aksu and Saygi (1990) reported that "with the changing role of women in society, math-anxiety is slowly moving in the direction of becoming an equal opportunity debility" (p. 391).

Hembree (1990) concluded:

> Across all grades, female students report higher mathematics anxiety levels than males. However, the higher levels do not seem to translate into more depressed performance or to greater mathematics avoidance on the part of female

> students. Indeed, male students in high school exhibit stronger negative behaviors in both these regards (p. 45).

Richardson and Suinn (1972) reported no significant differences between the mean scores or standard deviations for males and females in their report of psychometric data for the Mathematics Anxiety Rating Scale (MARS). Other researchers have reported similar results (Morris, Kellaway and Smith, 1978; Widmer and Chavez, 1982; Chavez and Widmer, 1982). Brush (1978) reported sex differences on MARS scores which were inconsistent between two samples.

Ernest (1976) reported no significant sex differences in grades achieved, even though he noted that enrollment of women in these courses was disproportionately low. Baya'a (1990) reported differences in male and female mathematics anxiety and mathematics performance, but found the causes to be due to societal influences rather than gender differences.

Gough (1954), in discussing the prevalence of mathemaphobia, wrote that it was "almost as common as the common cold" (p.290). Richardson and Suinn (1972) indicated that in a college population, mathematics anxiety is a fairly common problem, even among individuals who do not ordinarily suffer from any other anxieties. Lazarus (1974) indicated that the problem was nearly universal. Betz (1978) concluded that about 68 percent of students enrolled in mathematics classes experienced high mathematics anxiety.

This survey cites published material on the descriptions and definitions of mathematics anxiety, on the measurements of mathematics anxiety, and on studies describing mathematics anxiety in college students and preservice teachers.

I. DEFINITIONS AND DESCRIPTIONS OF MATHEMATICS ANXIETY

One of the first published articles to recognize and discuss the phenomenon which we now call mathematics anxiety was that of Sister Mary Fides Gough, in 1954. She described a condition which she called mathemaphobia as a major cause of failures in mathematics classes. However, she offered no formal definition for the condition, stating: "Mathemaphobia needs no defining. The term is self-definitive" (p. 290).

The term mathematics anxiety was neither frequently used nor well defined in the literature until the early 1970s, when Richardson and Suinn (1972) developed the MARS and, along with others, began to provide more precise definitions and to improve the instruments used to measure the phenomenon. They defined mathematics anxiety as involving "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). This definition has gained

general acceptance and is currently perhaps the most widely used definition. Subsequently, the phenomenon was generally identified as mathematics anxiety and the term began to appear in the literature more frequently.

Other early researchers, however, did provide descriptions and other definitions. Dreger and Aiken (1957), investigating number anxiety in college students, defined it as "a syndrome of emotional reactions to arithmetic and mathematics" (p. 344). Mitchell Lazarus (1974), describing mathophobia, called it "an irrational and impeditive dread of mathematics" (p. 16). He commented:

> Because research is scarce, anyone who would write on the subject of mathophobia has little choice but to fall back on personal observation and anecdotal evidence, at least for the time being. (p. 17)

Fennema and Sherman (1976) defined mathematics anxiety as "feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (p. 326). Tobias (1976) termed it an "I can't syndrome" (p. 57). Donady and Tobias (1977) labeled mathematics anxiety a "nonrational distaste for and avoidance of math and math-related subjects" (p. 71). According to Kogelman and Warren (1978), it is defined as "an intense emotional reaction to math based on past experiences" (p. 9).

In a textbook written for use in secondary mathematics methods courses, Ellis (1981) begins a chapter on mathematics anxiety with the following definition:

> Mathematics anxiety is a phobia. A phobia is an unreasonable fear response to particular events and situations. Like all phobias, mathematics anxiety is learned. (p.172)

Kennedy (1984) devotes one full chapter of his textbook for elementary teachers to the subject of mathematics anxiety. He provides still another definition: "Mathematics anxiety is a fear of mathematics created by conditions inside and outside of school that cause a person to avoid mathematics to some degree" (p. 73).

Sovchik, Meconi and Steiner, in 1981, still found the definition inadequate, however. They concluded that "It may be safely stated that mathematics anxiety is an illusive, ambiguous term in need of greater clarification" (p. 646).

Hembree (1990) asserted the need to "develop a scholarly base for the construct, assuring that treatments toward its relief coincide with its nature" (p. 34). He indicated that the research of mathematics anxiety had not been hindered by its lack of an independent definition, however, because it was perceived as a threat to both mathematics achievement and participation in mathematics.

II. MEASUREMENTS OF MATHEMATICS ANXIETY

Several instruments are available which purport to provide some measure of mathematics anxiety. Instruments which will be reviewed here are:

1. the Aiken-Dreger Revised Mathematics Attitude

Scale,

2. the Mathematics Attitude Inventory (MAI),

3. the Fennema-Sherman Mathematics Attitude Scales,

4. the Mathematics Anxiety Rating Scale (MARS),

5. the Revised Mathematics Anxiety Rating Scale (RMARS), and

6. the Mathematics Anxiety Rating Scale for Adolescents (MARS-A).

The Aiken-Dreger Revised Mathematics Attitude Scale

The revised twenty-item Aiken-Dreger Mathematics Attitude Scale (Aiken and Dreger, 1961) is a Likert-type rating form with five response choices for each item. Response choices range from strongly agree to strongly disagree. The test-retest reliability was reported as .94. Clark-Meeks, Quisenberry and Mouw (1982) confirmed the content validity of the scale, reporting that it was "univariate measuring one concept, mathematics attitude" (p.319). Adwere-Boamah, Muller and Kahn (1986) disagreed, concluding that the scale measured two separate factors related to attitude toward mathematics. They labeled the two factors "Enjoyment for and Fear of mathematics" (p. 236) and reported reliability coefficients of .93 and .87, respectively.

The Mathematics Attitude Inventory (MAI)

The Mathematics Attitude Inventory (MAI; Sandman, 1980) is designed to measure the attitude toward mathematics of secondary school students. Divided into six subscales, each scale is set up in a four-point Likert format. The MAI measures six constructs of mathematics attitude:

1. Perception of the Mathematics Teacher,
2. Anxiety toward Mathematics,
3. Value of Mathematics in Society,
4. Self-concept in Mathematics,
5. Enjoyment of Mathematics and
6. Motivation in Mathematics.

Sandman claimed support for the construct validity of the MAI but failed to provide specific data. Cronbach alpha reliability coefficients were reported, with a range of values between .68 and .89.

The Fennema-Sherman Mathematics Attitude Scales

The Fennema-Sherman Mathematics Attitude Scales (Fennema and Sherman, 1976) is composed of nine subscales, including a Mathematics Anxiety Subscale (MAS). This subscale was designed to be administered to high school students. It measures "feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (p. 4). It is a 12-item scale, using a five-point Likert format with responses for each item which range

from strongly agree to strongly disagree. Complete reliability and validity data for the Mathematics Attitude Scales was not presented by the authors.

In 1978, Betz reported a split-half reliability coefficient of .92 for the MAS. However, Rounds and Hendel (1980) stated that "the lack of reliability and validity data seriously impedes the use of these measures for research purposes" (p. 139). Suinn and Edwards (1982) concur.

The Mathematics Anxiety Rating Scale (MARS)

Developed for use in a college population, the Mathematics Anxiety Rating Scale (MARS; Richardson and Suinn, 1972) is a 98-item scale in a five-point Likert format. It is designed to measure "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Each item is a description of a situation which might arouse some level of math anxiety. Students indicate the degree of anxiety they feel in response to the described situation, using five weighted responses. The responses range from "Not at all" to "Very much" and are weighted from 1 (not anxious) to 5 (extremely anxious). Summation of the weighted responses provides the individual's score. Scores may range from 98 (low anxiety) to 490 (high anxiety).

Richardson and Suinn (1972) reported normative data for the MARS on a sample of 397 college students. They indicated a test-retest reliability coefficient of .85 and an internal consistency reliability coefficient of .97. In a separate validity study for a group of thirty university students, they compared scores on the MARS to their scores on the mathematics section of the Differential Aptitude Tests (DAT) and reported a correlation of -.64. This negative correlation coefficient was expected, indicating that a high level of anxiety coincides with low performance. Suinn, Edie, Nicoletti, and Spinelli (1972) reported similar reliability and validity data for the MARS, as did Brush (1978); Sovchik, Meconi and Steiner (1981); and Dew, Galassi and Galassi (1983).

Richardson and Suinn (1972) originally reported that the MARS was "heavily dominated by a single homogenous factor, presumably mathematics anxiety" (p. 553). However, subsequent researchers have found the MARS to be multi-dimensional. Brush (1978) reported identifying two factors which she called Problem-Solving Anxiety and Evaluation Anxiety. Morris, Kellway and Smith (1978) identified three subscales of the MARS which they termed Math Class Anxiety, Math Studying Anxiety, and Math Test Anxiety. Rounds and Hendel (1980) detected only two dimensions, which they labeled Mathematics Test Anxiety and Numerical Anxiety. Ferguson (1986) confirmed these same two dimensions, plus a

third, which he labeled "Abstraction Anxiety" (p. 149).

Richardson and Suinn (1972) reported no significant difference between the mean scores or standard deviations for males and females (p. 552). Sovchik, Meconi and Steiner (1981), in a study to determine the reliability of the Mathematics Anxiety Rating Scale (MARS) administered it as both a pretest and a posttest to fifty-nine prospective elementary school teachers enrolled in a methods course. The results indicated a reliability coefficient of .978 for the pretest and .982 for the posttest.

Revised Mathematics Anxiety Rating Scale (RMARS)

Plake and Parker (1982) developed a shortened version of the MARS "to provide a more efficient index of statistics or mathematics course-related anxiety" (p. 551). The Revised Mathematics Anxiety Rating Scale (RMARS) consists of twenty-four items selected from the ninety-eight items of the MARS. Subject response requirements and scoring procedures are identical to those for the MARS, using a numerical scale of one to five to indicate increasing levels of anxiety. The RMARS was found to include two factors of mathematics anxiety, paralleling those exhibited by the MARS. Plake and Parker labeled these two factors "Learning Mathematical Anxiety" and "Mathematics Evaluation Anxiety". They concluded:

The Revised Mathematics Anxiety Rating Scale

(RMARS) shows a pattern of relationships with measures of State, trait, and test anxiety and mathematics test achievement similar to that for the full-scale MARS. Having demonstrated an estimate of coefficient alpha reliability of .98, the Revised MARS is highly related to the full-scale MARS (the correlation having been estimated to be .97) (p. 556).

Mathematics Anxiety Rating Scale-A (MARS-A)

Suinn and Edwards (1982) developed a revised version of the MARS for use with adolescents, the Mathematics Anxiety Rating Scale-A (MARS-A). The MARS-A, like the MARS, is a 98-item Likert-type scale. It involves changes in some words or substitution of new items deemed more appropriate for adolescents. Two factors, labeled Numerical Anxiety and Mathematics Test Anxiety were identified, paralleling the results of the study of the MARS by Brush (1978) and by Rounds and Hendel (1980). The reliability coefficient for the MARS-A was reported as .90.

III. STUDIES DESCRIBING MATHEMATICS ANXIETY IN COLLEGE STUDENTS AND PRESERVICE TEACHERS

Dreger and Aiken (1957) found that 35 percent of the students tested at a large Florida university had high levels of number anxiety. They concluded that number anxiety was a separate construct from general anxiety, and that it did not seem to be related to general intelligence. It was, however, negatively related to mathematics grades.

Investigation of the mathematics anxiety experienced by

teachers and the relationship of teacher attitudes and anxiety to the attitudes and anxiety of students has been of interest to numerous researchers throughout the literature. In a review of the research which had been conducted during the 1960's, Aiken (1970) noted: "Of all the factors affecting student attitudes toward mathematics, teacher attitudes are viewed as being of particular importance" (p. 592). Later (1976), he acknowledged the difficulty in assessing the impact of teacher attitudes, stating: "The belief that teachers' attitudes affect students' attitudes toward mathematics has not been as easy to confirm as might be supposed" (p. 299).

Dutton (1962) administered an attitude scale to 127 preservice female elementary school teachers at the University of California, Los Angeles. He then compared those student responses with responses from a previous survey done in 1954. In both surveys, approximately 30 percent of the prospective elementary teachers responded that they were afraid of doing word problems. Approximately 38 percent of the sample responded that they did not feel sure of themselves in arithmetic, and 8 percent admitted that they had always been afraid of arithmetic.

Phillips (1973) administered the Dutton Attitude Toward Arithmetic Scale to 306 seventh grade students in a Virginia school district. He also administered Dutton's University

of California Arithmetic Scale to fifty-nine teachers who had taught some of the students in the sample. This study was designed to determine whether any relationship existed between teacher attitude, student attitude and student achievement in arithmetic. His findings provided "evidence that teacher's attitude toward arithmetic is significantly related to student attitude and achievement in arithmetic" (p. 507). He also found a significant relationship between the arithmetic attitude of a student's most recent teacher and the arithmetic attitude of the student.

Lazarus (1975) reported that "many teachers are themselves affected by mathophobia, sometimes admitting that they feel uncomfortable when they teach mathematics" (p. 46). Widmer and Chavez (1982) reported that 16 percent of their sample of 230 elementary teachers were math anxious. Hembree (1990), in a meta-analysis of 151 studies of mathematics anxiety, concluded that "the highest levels [of mathematics anxiety] occurred for students preparing to teach in elementary school" (p. 42).

Sovchik, Meconi and Steiner (1981) attempted to determine whether completion of a mathematics methods course lessened the degree of mathematics anxiety as measured by the MARS. The instrument was administered as both a pretest and a posttest to fifty-nine prospective elementary school teachers enrolled in a methods course. A dependent measures t-test yielded a value of 4.29, indicating a significant

decrease ($p < .05$) in mathematics anxiety.

Clark-Meeks, Quisenberry and Mouw (1982) conducted a study of sixty-four preservice teachers seeking certification in four different areas of concentration. The purpose of the study was to determine if there was any difference in mathematics attitude among the four different areas. They concluded that there were no significant differences between the four groups, but noted:

> These results indicate that, for the most part, prospective teachers still have unfavorable attitudes toward mathematics. The groups continue to experience strain, dislike, fear, insecurity and confusion when confronted with mathematics (p. 319).

A survey was conducted (Chavez and Widmer, 1982; Widmer and Chavez, 1982) among 230 elementary school teachers in five northern Kentucky counties to investigate the relationship between math anxiety and sex, career inhibition, type of training, and recency of training. Using a self-developed survey instrument, the researchers reported:

1. no significant relationship between mathematics anxiety and sex,

2. a significant relationship ($p < .05$) between mathematics anxiety and the inhibition of career goals,

3. a significant relationship ($p < .05$) between the type of training the teachers had received and the number who showed mathematics anxiety, and

4. no significant relationship between mathematics anxiety and recency of training.

In a series of follow-up interviews, the researchers noted that the interviewees "consistently gave evidence of attitudes towards mathematics being linked to attitudes and behaviors of mathematics teachers" (Widmer and Chavez, 1982, p. 275). They found no evidence that attitudes toward mathematics had been a primary consideration in choosing teaching as a profession.

Bulmahn and Young (1982) conducted a survey of "over 200 students" of whom "roughly half were prospective elementary teachers" (p. 55). Their survey consisted of a questionnaire and, for the elementary education students, an essay on attitudes toward mathematics. They reported several trends in the essays which they found disturbing:

1. Students frequently indicated that "math has always been my worst subject", or milder versions of that statement.

2. Many students admitted that their career options had been limited by their mathematical abilities.

3. Many students admitted to a real fear of word problems.

4. Many beginning education students expressed the feeling that elementary teachers do not really have to be very good at mathematics beyond the basic computations.

The researchers then posed the following questions:

> Is a teacher's interest in (or fear of) a subject contagious? Is "math anxiety" a communicable disease that is being carried by elementary teachers to generations of the student population (p. 56)?

Clute (1984) investigated the effect of different methods of instruction on mathematics anxiety and the relationship of mathematics anxiety with mathematics achievement as measured by the University of California and California State University Mathematics Test. She found that students with high mathematics anxiety tended to score lower on the test than did students with lower levels of mathematics anxiety. Additionally, she concluded that students with low mathematics anxiety tended to do better under the discovery method of teaching while students with high mathematics anxiety tended to do better under the expository method.

Gadzella and Davenport (1985) investigated differences between men and women in mathematics achievement, relationships between attitudes toward mathematics and mathematics achievement in a sample of 218 freshman college students. Mathematics achievement was defined as the end of semester grade. They found that college men differed significantly from college women in mathematics achievement and that women obtained higher grades in mathematics courses. It was noted that the majority of students in the study were pursuing elementary or secondary teaching

certificates. They concluded that gender and freedom from fear in mathematics (anxiety) were the two best predictors of mathematics achievement.

Kelly and Tomhave (1985), at a small liberal arts college in Minnesota, attempted to measure the extent to which mathematics avoiders suffered from mathematics anxiety. Their sample purposely included students likely to be mathematics avoiders. One group consisted of students who were enrolled in a workshop for the math anxious. The Mathematics Anxiety Rating Scale (MARS) was administered to determine the level of mathematics anxiety and the following results were noted:

1. The elementary education females exhibited higher mathematics anxiety than any group except those in the mathematics anxiety workshop.

2. One male group of elementary education majors exhibited lower mathematics anxiety than any other group.

3. The three elementary education groups exhibited higher mathematics anxiety than any other group except those in the mathematics anxiety workshop.

Kelly and Tomhave (1985) concluded:

> If the results of our study are representative of preservice teacher education, then women elementary school teachers, who constitute the majority of elementary school teachers, may be perpetrating math anxiety with young girls in their own classrooms (p.52).

Becker (1986) reported a study of the mathematics

attitudes of 172 students at a large public university. The sample was 95 percent female and included eighty-one elementary education majors and seventy-one students enrolled in a general astronomy course. A revised version of the Fennema-Sherman Mathematics Attitude Scales was administered, using only seven of the nine available scales and omitting certain items considered not applicable for college students.

Although the reported results indicated that the education students were more math anxious than the astronomy students and that they scored lower on the anxiety scale than on any other scale, Becker points out that the differences are, in fact, very small and offers the opinion that "we may be expecting too much if we want education students to be more positive about mathematics than college students in general" (p. 51).

Battista (1986) conducted a study to examine whether or not preservice teachers mathematical knowledge and mathematics anxiety would affect their success in a mathematics methods course and whether or not a mathematics methods course could reduce the mathematics anxiety of preservice teachers. The sample consisted of seventy-four preservice elementary teachers enrolled in four sections of a mathematics methods course. The Mathematics Anxiety Rating Scale (MARS) was administered both as a pretest and

as a posttest measure of mathematics anxiety. The Mathematical Competency Test was administered to assess knowledge of mathematics prior to the course. Results indicated a significant reduction in mathematics anxiety as a result of taking the methods course. Mathematical knowledge was significantly related to successful learning of mathematical pedagogy, but was not related to student success in teaching during a field experience. Mathematics anxiety did not appear to inhibit the learning of mathematical pedagogy.

Hembree (1990) conducted a meta-analysis of 151 studies of mathematics anxiety, including 122 which dealt with postsecondary students. He reported the following:

1. mathematics anxiety is related to poor performance on mathematics achievement tests;

2. mathematics anxiety is bound directly to avoidance of mathematics;

3. variables which can affect levels of mathematics anxiety include ability, grade level and undergraduate field of study;

4. preservice elementary teachers are especially prone to mathematics anxiety;

5. females display higher levels of mathematics anxiety than do males, even though precollege males appear to suffer more adverse effects from mathematics anxiety; and

6. improved mathematics performance consistently

accompanies valid treatment of mathematics anxiety.

He also found mathematics anxiety inversely correlated with mathematics achievement, mathematics performance and the number of mathematics courses taken.

In summary, most of the literature indicates that mathematics anxiety is negatively related to mathematical performance (Dreger and Aiken, 1957; Richardson and Suinn, 1972; Brush, 1978; Morris et al., 1978; Betz, 1978; Suinn and Edwards, 1982; Green, 1990; Hembree, 1990). However, Rounds and Hendel (1980) disagreed, stating that in spite of the near unanimity of opinion, little or no actual evidence had been presented.

Most studies indicate that education majors, and in particular elementary education majors, exhibit a higher level of mathematics anxiety than other groups of college students (Dutton, 1962; Clark-Meeks et al., 1982; Bulmahn and Young, 1982; Kelly and Tomhave, 1985; Becker, 1986; Meece, Wigfield and Eccles, 1990; Hembree, 1990).

There seems to be general agreement in the literature that student attitudes toward mathematics are affected by teacher attitudes and mathematics anxiety (Phillips, 1973; Brush, 1981; Widmer and Chavez, 1982; Larson, 1983; Kelly and Tomhave, 1985).

There is some evidence that completion of a mathematics methods course reduces mathematics anxiety in preservice

teachers (Sovchik et al., 1981; Battista, 1986).

Although some researchers found differences in the mathematics anxiety levels of males and females (Betz, 1978; Dew et al., 1983; Kelly and Tomhave, 1985; Hembree, 1990), other researchers found no significant differences in mathematics anxiety between males and females (Richardson and Suinn, 1972; Tobias and Weissbrod, 1980; Widmer and Chavez, 1982).

Some studies indicate that career options can be limited by mathematical abilities (Sells, 1978; Bulmahn and Young, 1982; Kelly and Tomhave, 1985; Meece et al., 1990).

CHAPTER III

METHOD

This chapter describes the subjects who participated in the study, the instrument used to measure mathematics anxiety in the study, the courses from which the subjects were solicited and the procedures which were used in the study.

I. THE PARTICIPANTS IN THE STUDY

The participants in this study were students at The University of Tennessee, Knoxville campus, during the Winter Quarter of 1987. These students were enrolled in:

1. Mathematics 1540 (College Algebra),
2. Mathematics 1840 (Single Variable Calculus),
3. Mathematics 2120 (Structure of the Number System),
4. Curriculum and Instruction 3350 (Teaching Elementary School Mathematics),
5. Curriculum and Instruction 3752 (Teaching of Mathematics: Geometry and Analysis, Grades 7-12),
6. Curriculum and Instruction 5290 (Teaching of Mathematics in the Elementary School), or
7. English 1020 (English Composition).

The initial sample of 337 students was composed of approximately 39% males and 61% females. Within most of the major groups, however, the distribution of males and females was even more skewed toward female dominance. The only predominantly male group was the Technical Group (84% males and 16% females). All other groups were clearly predominantly female.

Of the 125 subjects who were finally included as participants in the study, approximately 12% were in the Control Group (CONTROL), 15% were in the Technical Group (TECH), 18% were in the Nontechnical Group (NONTECH), 38% were in the Elementary Education (Undergraduate) Group (ELEM ED[U]), 5% were in the Elementary Education (Graduate) Group (ELEM ED[G]), 6% were in the Mathematics Education Group (MATH ED), and 6% were in the General Education Group (GENERAL ED).

During the first two weeks of school during the Winter Quarter, the investigator visited each of the selected classes and read a prepared written statement explaining the purpose and the conduct of the study to the students. (A copy of this statement is included in Appendix A). All students who volunteered to participate were required to sign a written consent form and to indicate whether they were 18 years old or older. Any volunteers who were not at least 18 years old were not included as participants in the study. All volunteers who were at least 18 years old were

required to complete a Student Information Sheet (SIS) and to complete the Revised Mathematics Anxiety Rating Scale (RMARS). Nonvolunteers were requested to complete the SIS anonymously. Data from each SIS was used to determine which of the 337 volunteers could participate in the study. Criteria for rejection as a participant are listed below:

1. Any student who was not at least 18 years old at the time the SIS was completed was rejected prior to the initial administration of the RMARS. Although University of Tennessee approval for the study had been obtained, this was done to avoid any possible problems involving parental consent for minors.

2. Any student who did not complete the information requested on the SIS was rejected. This was done to ensure that all data items would be available for all participants in the study.

3. Any student who was repeating the mathematics-related course because of a previous grade of D or F was rejected. This was done because repeating a previously failed course might affect the student's level of mathematics anxiety.

4. Any undergraduate student whose ACT mathematics subtest score was not available was rejected. (Most graduate students did not have ACT scores, so no graduate student was rejected for that reason.)

5. Any student who did not complete the RMARS on both the initial and the final day of administration was rejected. This was to ensure that all participants would have both a pretest and a posttest RMARS score for comparison purposes.

6. Any student enrolled in one of the selected mathematics-related courses who did not receive a final grade for the course was rejected. This was done to ensure that all participants had completed the mathematics-related course.

7. Any student who had previously participated in any type of mathematics anxiety treatment program was rejected. This was done because previous participation in such a program could affect the student's level of mathematics anxiety.

8. Any student in one of the mathematics-related classes who was concurrently enrolled in any other mathematics-related course was rejected. This was done to ensure that any changes in pretest and posttest RMARS scores involved only one mathematics-related course.

9. Any student in the Control Group (volunteers from English 1020) who was enrolled in any mathematics-related course was rejected. This was done to ensure that any changes in pretest and posttest RMARS scores for the Control Group did not involve any mathematics-related course.

Application of these criteria resulted in rejection of

about 63% of the initial volunteers. Of 337 subjects who initially volunteered to participate in the study, 212 were rejected. Table 1 summarizes the data relevant to these rejections.

Almost 30% of the rejections were students in the Control Group who were also enrolled in a mathematics-related course. More than 20% of the rejections were for lack of an ACT score. No graduate students were rejected however, since ACT scores were not required of most graduate students. More than 24% of the rejections were because the RMARS was not completed both times. Approximately 13% were rejected because they were repeating the mathematics-related course. The remaining 13% were either enrolled in another mathematics-related course or failed to complete the SIS.

Because of concern about possible bias due to the large number of students who were rejected, *t*-tests for independent samples were conducted, comparing the mean pretest RMARS scores of the students who were rejected and the students who were included in the study. Similar tests were conducted comparing the mean posttest RMARS scores of the two groups. No significant differences were noted in either case.

In order to obtain some measure of the effect of rejecting those students who were not 18 years old, a one-way analysis of variance was performed, using the students

TABLE 1

BREAKDOWN OF REJECTED STUDENTS BY REASON

		Reason for Rejection						
Group	Initial	1	2	3	4	5	6	Analyzed
CONTROL	103[a]	0	6	3	8	9	0	15
TECH	38	2	1	1	5	5	5	19
NONTECH	82	1	3	5	17	16	17	23
ELEM ED(U)	74	1	0	1	12	9	4	47
ELEM ED(G)	12	2	2	0	0	2	0	6
MATH ED	17	8	0	0	1	0	0	8
GENERAL ED	9	0	0	0	0	0	2	7
(NO MAJOR)	2	0	2	0	0	0	0	0

Note. Key to reasons for rejection:

1: was enrolled in an additional mathematics course

2: did not complete Student Information Sheet (SIS)

3: did not complete RMARS (pretest)

4: did not have ACT mathematics subtest score

5: did not complete RMARS (posttest)

6: was repeating this mathematics-related course

[a]For the Control Group, any student enrolled in a mathematics-related course was not included in the study. Sixty-two students were rejected for this reason.

who were participants.

In this analysis, age was used as the independent variable and pretest RMARS score was the dependent variable. No significant differences in pretest RMARS scores were noted among the fifteen different age levels represented. There seemed to be no relationship, either positive or negative, between age and mathematics anxiety as measured by the RMARS.

II. THE INSTRUMENTS USED IN THE STUDY

Revised Mathematics Anxiety Rating Scale (RMARS)

The Revised Mathematics Anxiety Rating Scale (RMARS), a 24-item version of the 98-item Mathematics Anxiety Rating Scale (MARS), was used to measure the mathematics anxiety of each participant in the study. Plake and Parker (1982) reported that the RMARS was developed as a more efficient index of mathematics-course anxiety than the full scale MARS.

Each item on the 24-item scale describes a situation or an experience with mathematics which may arouse anxiety within a subject. The subject decides the degree of anxiety aroused by the situation described and then selects an appropriate response from the five responses available on the RMARS. The subject may respond that he feels "Not at all", "A little", "A fair amount", "Much", or "Very much" frightened by the situation.

Although it is recognized that these responses constitute ordinal data, the investigator followed common practice by assuming that they could be converted to interval data by assigning numerical values to each response. A numerical value of 1 was assigned for "Not at all", 2 for "A little", 3 for "A fair amount", 4 for "Much" and 5 for "Very much". Thus, each of the 24 items of the RMARS takes on a value between 1 and 5. The RMARS score is the sum of these values and could range from 24 to 120. (A copy of the RMARS is included in Appendix A).

Plake and Parker (1982) provided information on the development and validation of the RMARS. Their normative data was collected from a sample of 170 undergraduates and graduate students enrolled in introductory statistics classes at a large urban midwestern university. The mean RMARS score for the sample was 59.84, with a standard deviation of 20.55. The internal consistency (coefficient alpha) reliability of the RMARS was 0.98.

Plake and Parker reported that the correlation coefficient between the MARS and the RMARS was estimated to be .97. They also found that the RMARS presented a clear, two-factor pattern similar to the MARS. The two factors, identified as Learning Mathematics Anxiety and Mathematics Evaluation Anxiety, accounted for 60% of the total variance.

A 48-item Mathematics Achievement Test (MAT) was also

administered to the subjects in order to determine the validity of the RMARS. This test was made up of items associated with the ACT mathematics subtest and provided a reliability coefficient (Kuder-Richardson formula 20) of 0.91. The correlation coefficient between the RMARS and the MAT was -0.45.

Student Information Sheet (SIS)

The Student Information Sheet (SIS) was developed by the investigator. Administered to each participant, it provided information with regard to (a) age, (b) sex, (c) major area of study, (d) concurrent enrollment in other mathematics-related courses, (e) highest level of mathematics successfully completed, (f) date of completion for most recent successful mathematics course, (g) previous involvement in a mathematics anxiety treatment program, and (h) previous unsuccessful enrollments in the mathematics-related course. (A copy of the Student Information Sheet is included in Appendix A).

In order to evaluate the highest level of mathematics course completed, the number of high school and college mathematics courses successfully completed, as indicated on the SIS, was counted and the total number of courses was used as the measure of mathematics background.

III. THE COURSES INVOLVED IN THE STUDY

No student who participated in the study as a member of the Control Group was enrolled in any mathematics-related course. Except for those Control Group members, all participants in the study were enrolled in a mathematics-related course. This section provides a brief description of the areas taught in each course and, where applicable, the prerequisite courses for the course.

Mathematics 1540 (College Algebra)

The topics taught in Mathematics 1540 were: sets, real and complex numbers, exponents and radicals, fundamental algebraic operations, theory of equations, polynomial inequalities, relations, functions and graphs. Prerequisites for Mathematics 1540 were either two years of high school algebra or one year of algebra and one year of geometry.

Mathematics 1840 (Single Variable Calculus)

The topics covered in Mathematics 1840 were: functions, graphs, slope of a curve, definition of a derivative, limits, derivatives of algebraic functions, implicit differentiation, chain rule, differentials, continuity, applications of derivatives, and maxima and minima. Prerequisites for Mathematics 1840 were two years of high school algebra, one year of geometry, and one-half

year of trigonometry or the equivalent.

Mathematics 2120 (Structure of the Number System)

The topics covered in Mathematics 2120 were: inverses, order properties, rational numbers. Prerequisites for Mathematics 2120 were one year of high school algebra and either sophomore standing in elementary education or the consent of the instructor.

Curriculum and Instruction 3350 (Teaching Elementary School Mathematics)

Curriculum and Instruction 3350 enabled preservice teachers to develop skills and understandings necessary for operation of successful mathematics programs in the elementary school. This course was required for teacher certification in elementary education. Prerequisites for Curriculum and Instruction 3350 were Mathematics 2110-20-30 and admission to the Teacher Education Program.

Curriculum and Instruction 3752 (Teaching of Mathematics: Geometry and Analysis, Grades 7-12)

The topics covered in Curriculum and Instruction 3752 were: purposes, techniques, materials, and evaluation; directed observation in public schools; and preparation of teaching plans and materials. This course was required for teacher certification in mathematics education. The prerequisite for Curriculum and Instruction 3752 was

admission to the Teacher Education Program.

Curriculum and Instruction 5290 (Teaching of Mathematics in the Elementary School)

Topics covered in Curriculum and Instruction 5290 were: mathematics in the elementary school; foundations for effective teaching; assessment procedures for mathematics; mathematics anxiety; problem solving; calculators and computers; teaching the foundations of numeration; extending understanding of numeration; introducing addition and subtraction; extending the operations of addition and subtraction; teaching multiplication and division; working with fractional numbers (common fractions); fractional numbers (decimals and percentages); measures and the process of measuring; informal geometry; elementary number theory, probability, statistics and graphs; and planning for teaching. The prerequisite for Curriculum and Instruction 5290 was the consent of the instructor.

English 1020 (English Composition)

English 1020 was selected to provide students for the Control Group because English 1020 was required for most students at the University of Tennessee, Knoxville, regardless of major. This provided access to a wide range of majors for inclusion in the Control Group. In addition, because the course had no mathematical prerequisites, some students were available who were not concurrently enrolled

in a mathematics-related course.

IV. PROCEDURES USED IN THE STUDY

During the first two weeks of the Winter Quarter, 1987, the investigator visited each of the 17 class sections from which participants were to be drawn. The investigator read to each class a prepared introductory statement which briefly described the proposed research and solicited voluntary participation. Volunteers were required to sign a consent form to certify that they were at least eighteen years of age and to authorize access to their grade for the course and access to their ACT mathematics subtest scores. The investigator then administered the SIS and the pretest RMARS to those volunteers who were at least eighteen years old. Nonvolunteers were requested to complete the SIS anonymously. (Copies of the introductory statement, the consent form, the SIS and the RMARS are contained in Appendix A).

Each administration of the RMARS was accomplished in the same classroom where each class normally met and at the same time they normally met. To encourage honest answers, students were assured that both student and instructor anonymity would be preserved throughout the study. The normal classroom instructors were not required to be present during the administration of the surveys and they were not

provided access to the survey forms.

The participants met with their regular classes at the regular class times and followed the normal curriculum for their respective courses of instruction throughout the remainder of the quarter. During the last week of classes during that quarter, the investigator again visited each class and administered the posttest RMARS to the participants under the same conditions.

During the following quarter, the instructor of each of the mathematics-related classes provided the investigator with course grade data for the participants from their respective courses. The ACT mathematics subtest scores for each participant were requested and received from The University of Tennessee using routine administrative procedures.

V. SUMMARY

The purpose of this chapter was to describe the participants in the study, to provide information about the RMARS and the SIS, and to outline the procedures which were used by the investigator in conducting the study.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter discusses the results of the preliminary *t*-tests and analysis of variance used to evaluate possible bias in the sample; the analysis of variance of the scores on the Revised Mathematics Anxiety Scale (RMARS); the changes in levels of mathematics anxiety, as measured by the RMARS, from initial testing to final testing; and the degree of relationship between RMARS scores and the factors of mathematics background, mathematics achievement, mathematics performance and mathematics avoidance.

Possible Sources of Bias

The use of volunteers was considered as a likely source of bias in this study and an attempt was made to assess any differences between the participants and the nonvolunteers. The *t*-test for independent samples was used to compare the age, avoidance of mathematics and mathematics background data of the nonvolunteers with that of the participants. No significant differences were found in age, avoidance of mathematics or mathematics background between the participants and the nonvolunteers.

Another possible source of bias considered was the

exclusion of students younger than 18 years of age. To assess this, an analysis of variance using RMARS score as the dependent variable and age as the independent variable was conducted. Although the ages of the participants ranged from 18 years to 43 years in fifteen different levels, no significant differences in RMARS scores were found.

One additional concern was the large number of subjects who were rejected as participants. The t-test for independent samples was used to compare the mean pretest RMARS score of the rejected students with the mean pretest RMARS score of the participants. A similar comparison was done for the mean posttest scores of the two groups. No significant differences were found between the two groups in either case.

I. ANALYSIS OF THE REVISED MATHEMATICS ANXIETY RATING SCALE

Experimental Design for the Two-way Analysis of Variance

Participants in the study completed the Revised Mathematics Anxiety Rating Scale and were then grouped by their college major. The seven groups were: (1) the Control Group (CONTROL), (2) the Technical Majors Group (TECHNICAL), (3) the Nontechnical Majors Group (NONTECH), (4) the Elementary Education (Undergraduate) Group (ELEM ED[U]), (5) the Elementary Education (Graduate) Group (ELEM

ED[G]), (6) the Mathematics Education Group (MATH ED), and (7) the General Education Group (GEN ED).

The RMARS scores were analyzed using a two-way analysis of variance. Sex of the student (male or female) and Group (as outlined above) were the independent variables with RMARS score as the dependent variable. Two groups, the General Education Group and the Elementary Education (Undergraduate) Group, were not included in the two-way analysis because each group had less than two male members. This resulted in a 2 X 5 factorial design for the two-way analysis of variance.

Hypotheses Tested by the Two-way Analysis of Variance

Three hypotheses were tested by the two-way analysis of variance:

H_o1: There are no significant differences in RMARS mean scores between males and females.

H_o2: There are no significant differences in the RMARS mean scores between the Control Group, the Technical Group, the Nontechnical Group, the Elementary Education (Graduate) Group, and the Mathematics Education Group.

H_o3: The interactions are each zero.

Results of the Two-way Analysis of Variance

Table 2 shows the mean, the standard deviation, and the number of subjects in each of the ten categories. Table 3

TABLE 2

MEANS AND STANDARD DEVIATIONS OF INITIAL RMARS SCORES FOR EACH GROUP (MALES AND FEMALES)

	MALES			FEMALES		
GROUP	n	M	SD	n	M	SD
CONTROL	6	68.00	19.21	9	63.56	14.58
TECH	16	45.00	14.07	3	52.67	2.89
NONTECH	4	46.00	15.75	19	54.84	13.71
ELEM ED(U)	1	54.00	0.00	46	57.98	17.54
ELEM ED(G)	2	54.00	14.14	4	66.50	14.82
MATH ED	3	50.00	7.94	5	46.60	9.48
GEN ED	0	--[a]	--	7	50.14	13.35

Note. Score on RMARS may range from 24 to 120. Higher RMARS scores indicate higher levels of mathematics anxiety.
[a]No male students in the General Education Group

TABLE 3

SUMMARY TABLE FOR TWO-WAY ANALYSIS OF VARIANCE OF MEAN SCORES FOR THE RMARS

SOURCE OF VARIATION	SUM OF SQUARES	df	MEAN SQUARE	F
SEX (S)	145.46	1	145.46	.74
GROUP (G)	3295.96	4	823.99	4.19 **
S X G	562.49	4	140.62	.72
ERROR	12005.62	61	196.81	
TOTAL	16520.31	70		

**$p < .01$.

summarizes the two-way analysis of variance.

The results of the analysis of variance show a significant ($p < .01$) group effect, so the null hypothesis for the group effect was rejected. The results however,show neither a significant sex effect nor a significant interaction effect. Therefore, the null hypotheses for the sex effect and the interaction effect were not rejected.

Results of Scheffe's Test

Since the group effect was the only significant effect for the analysis of variance, Scheffe's method was used to compare the group means. Figure 1 provides two significant results:

1. A significant difference exists between the mean of the Control Group and the means of the Technical Group, the Mathematics Education Group, and the Nontechnical Group.

2. A significant difference exists between the mean of the Elementary Education (Graduate) Group and the means of both the Technical Group and the Mathematics Education Group.

Discussion of the Results

1. No sex-related differences in mathematics anxiety were found. This disagrees with some previous studies (Betz, 1978; Dew, Galassi and Galassi, 1983), but supports the findings of others, including the developers of the MARS (Richardson and Suinn, 1972; Widmer and Chavez, 1982).

TECH	MATH ED	NONTECH	ELED(G)	CONTR
46.21	47.88	53.30	62.33	65.33

Note. Means which are underlined by the same line are not significantly different ($p < .05$).

Key:

TECH: Technical Group

MATH ED: Mathematics Education Group

NONTECH: Nontechnical Group

ELED(G): Elementary Education (Graduate) Group

CONTR: Control Group

Figure 1. Results of Scheffe's test, comparing mean pretest RMARS scores of the groups shown, subsequent to a two-way analysis of variance significant at $p < .01$.

2. The ten pair-wise comparisons produced significant differences between five pairs of RMARS means. The level of mathematics anxiety found in the Control Group was significantly higher ($p < .05$) than the mathematics anxiety in either the Technical Group, the Mathematics Education Group, or the Nontechnical Group. (The difference between the Control Group and both the Technical Group and the Mathematics Education Group was significant; $p < .01$.)

The level of mathematics anxiety found in the Elementary Education (Graduate) Group was significantly higher ($p < .05$) than the mathematics anxiety of either the Technical Group or the Mathematics Education Group. The Technical Group had the lowest RMARS scores and the Mathematics Education Group had the next higher scores. The Control Group had the highest RMARS scores, followed by the Elementary Education (Graduate) Group and the Nontechnical Group.

3. No significant interactions between group and sex were found.

Experimental Design for the One-way Analysis of Variance

Because of the number of male subjects in the General Education Group ($n = 0$) and the Elementary Education (Undergraduate) Group ($n = 1$), they were not included in the two-way analysis of variance. Therefore, a one-way analysis of variance, ignoring sex differences, was designed to

include these two groups in a comparison with the five groups used in the two-way analysis.

Hypothesis Tested by the One-way Analysis of Variance. The one-way analysis of variance tested the following hypothesis:

H_o2a: There are no significant differences in RMARS mean scores between the Control Group, the Technical Group, the Nontechnical Group, the Elementary Education (Undergraduate) Group, the Elementary Education (Graduate) Group, the Mathematics Education Group, and the General Education Group.

Results of the One-Way Analysis of Variance

Table 4 shows the mean and standard deviation for each group involved in the one-way analysis of variance. Table 5 summarizes the analysis of variance. The results indicate a significant ($p < .01$) group effect; therefore, the null hypothesis was rejected.

Scheffe's Test Results

Twenty-one pair-wise comparisons of the group means were made in order to determine where the significant differences ($p < .05$) occurred. Significant differences were found in seven of the 21 comparisons. Figure 2 shows the results of Scheffe's multiple comparison test.

The level of mathematics anxiety in the Control Group was found to be significantly higher than the level of

TABLE 4

MEANS AND STANDARD DEVIATIONS OF SCORES ON THE RMARS FOR EACH GROUP

GROUP	n	MEAN	STANDARD DEVIATION
CONTROL	15	65.33	16.07
TECH	19	46.21	13.20
NONTECH	23	53.30	14.12
ELEM ED(U)	47	57.89	17.36
ELEM ED(G)	6	62.33	14.61
MATH ED	8	47.88	8.51
GENERAL ED	7	50.14	13.35

Note. Higher score on RMARS indicates higher level of mathematics anxiety. Minimum possible score is 24; maximum possible score is 120.

TABLE 5

SUMMARY TABLE FOR ONE-WAY ANALYSIS OF VARIANCE OF MEAN SCORES FOR THE RMARS

SOURCE OF VARIATION	SUM OF SQUARES	df	MEAN SQUARE	F
GROUP	4411.55	6	735.26	3.14 **
ERROR	27646.89	118	234.30	
TOTAL	32058.44	124		

**$p < .01$.

TECH	MATH ED	GEN ED	NONTECH	ELED(U)	ELED(G)	CONTR
46.21	47.88	50.14	53.30	57.89	62.33	65.33

Note. The means underlined by the same line are not significantly different at $p < .05$.

Key:

TECH: Technical Group

MATH ED: Mathematics Education Group

GEN ED: General Education Group

NONTECH: Nontechnical Group

ELED(U): Elementary Education (Undergraduate) Group

ELED(G): Elementary Education (Graduate) Group

CONTR: Control Group

Figure 2. Results of Scheffe's test, comparing group means of pretest RMARS scores of the groups shown, following a one-way analysis of variance significant at $p < .01$.

mathematics anxiety in (1) the Nontechnical Group, (2) the General Education Group, (3) the Mathematics Education Group, and (4) the Technical Group. The level of mathematics anxiety in the Elementary Education (Graduate) Group was found to be significantly higher than the level of mathematics anxiety in (1) the Mathematics Education Group and (2) the Technical Group. The level of mathematics anxiety found in the Elementary Education (Undergraduate) Group was significantly higher than the level of mathematics anxiety in the Technical Group.

Discussion of the Results

As outlined above, the level of mathematics anxiety was found to be significantly different ($p < .05$) in seven of the 21 pair-wise comparisons. The Control Group, which had the highest level of mathematics anxiety as measured by the RMARS, accounted for more than half of these differences. These students, who were not enrolled in a mathematics-related course, had significantly higher mathematics anxiety than did the Technical Group, the Mathematics Education Group, the General Education Group or the Nontechnical Group. Only the two groups of Elementary Education majors had levels of anxiety which were not significantly lower than the Control Group. In general, Control Group participants tended to have less mathematical background, lower mathematics achievement and higher mathematics avoidance than those

groups with which they differed significantly.

The two Elementary Education Groups (Undergraduate and Graduate) accounted for the remaining significant differences which were found. The Elementary Education (Graduate) Group, which had the second highest level of mathematics anxiety, demonstrated a level of mathematics anxiety which was significantly different from both the Technical Group and the Mathematics Education Group. This group had the lowest measure of mathematics background of any of the seven groups and also had the highest measure of mathematics avoidance of any group.

The mathematics anxiety level of Elementary Education (Undergraduate) was significantly higher than the Technical Group. This group had the second lowest mean ACT scores of any group, exceeded by every group except the Control Group, and had the second highest measure of mathematics avoidance, exceeded only by the Elementary Education (Graduate) Group.

II. CHANGES IN LEVELS OF MATHEMATICS ANXIETY

The initial administration of the RMARS, accomplished during the first two weeks of class, was used as a pretest for that part of the study which attempted to determine whether successful completion of a mathematics-related course would affect the level of mathematics anxiety. The final administration of the RMARS, accomplished during the last week of classes in the quarter, was used as a posttest. Only

students who successfully completed the mathematics-related course were included in this part of the study. Successful completion required a grade for the course of 2.0 or higher. Table 6 shows the number of failures and successful completions in each group, for both males and females.

Hypotheses Tested by the t-test

A t-test for paired samples was used to analyze the data. The t-test tested the following hypotheses:

H_o4: There are no significant differences between pretest RMARS means and posttest RMARS means within any group.

H_o5: There are no significant differences between pretest RMARS means and posttest RMARS means for males and females within any group.

Results of the t-test

Table 7 lists the means and standard deviations of the pretest and posttest for each group. Only the Nontechnical Group showed a significant difference between pretest and posttest means.

Table 8 lists the means and standard deviations of the pretest and posttest for the males only. The Elementary Education (Undergraduate) Group and the General Education Group were not included because they contained one and zero males, respectively. No significant differences were found

TABLE 6

MATHEMATICS-RELATED COURSE COMPLETIONS
BY GROUP AND SEX

	SUCCESSFUL		UNSUCCESSFUL	
GROUP	MALES	FEMALES	MALES	FEMALES
CONTROL	6	9	--[a]	--
TECH	11	2	5	1
NONTECH	4	16	0	3
ELEM ED(U)	1	43	0	3
ELEM ED(G)	2	4	0	0
MATH ED	3	5	0	0
GENERAL ED	0	7	0	0

Note. Except for Control Group members, successful completion required a final grade of 2.0 or higher.
[a]Control group members were not enrolled in a mathematics-related course.

TABLE 7

THE *t*-TESTS FOR DIFFERENCES BETWEEN PRETEST AND POSTTEST MEANS OF THE RMARS FOR EACH GROUP

GROUP	*n*	PRETEST	POSTTEST	DIFFERENCE	*t*
CONTROL	15	65.33	68.87	3.53	1.76
TECH	13	45.54	47.38	1.85	0.89
NONTECH	20	50.20	56.00	5.80	2.73 *
ELEM ED(U)	44	57.89	56.32	-1.57	-1.08
ELEM ED(G)	6	62.33	64.67	2.33	0.56
MATH ED	8	47.88	49.50	1.63	0.59
GENERAL ED	7	50.14	54.71	4.57	1.38

*$p < .05$.

TABLE 8

THE *t*-TESTS FOR DIFFERENCES BETWEEN PRETEST AND POSTTEST MEANS OF THE RMARS FOR FIVE GROUPS (MALES ONLY)

GROUP	*n*	PRETEST	POSTTEST	DIFFERENCE	*t*
CONTROL	6	68.00	70.00	2.00	0.68
TECH	11	44.09	47.00	2.91	1.27
NONTECH	4	46.00	48.00	2.00	1.02
ELEM ED(G)	2	54.00	59.00	5.00	1.25
MATH ED	3	50.00	52.67	2.67	0.69

Note. No significant differences. Elementary Education (Undergraduate) Group and General Education Group are not included due to number of male subjects ($n = 1$ and $n = 0$, respectively).

between pretest and posttest means for any group.

Table 9 lists the mean and standard deviations of the pretest and posttest of all seven groups for the females only. The results show a significant difference between pretest and posttest means for the Nontechnical Group.

Discussion of the results

1. None of the groups showed a significant decrease in mathematics anxiety as measured by the RMARS. The only significant ($p < .05$) change in pretest and posttest means was an increase in mathematics anxiety in the Nontechnical Group. Mathematics anxiety increased for the Nontechnical Group as a whole and for the females in the Nontechnical Group.

2. For the males in the study, mathematics anxiety increased in every case, even though the differences were not statistically significant.

3. The only groups in which actual decreases in RMARS scores were found between pretest and posttest were the Elementary Education (Undergraduate) Group, both for the group as a whole and for the females in the group, and the for the females in the Technical Group. None of these decreases were at a significant ($p < .05$) level.

TABLE 9

THE *t*-TESTS FOR DIFFERENCES BETWEEN PRETEST AND POSTTEST MEANS OF THE RMARS FOR EACH GROUP (FEMALES ONLY)

GROUP	*n*	PRETEST	POSTTEST	DIFFERENCE	*t*
CONTROL	9	63.56	68.11	4.55	1.63
TECH	2	53.50	49.50	-4.00	-1.33
NONTECH	16	51.25	58.00	6.75	2.62 *
ELEM ED(U)	43	57.98	56.26	-1.72	-1.17
ELEM ED(G)	4	66.50	67.50	1.00	0.16
MATH ED	5	46.60	47.60	1.00	0.25
GENERAL ED	7	50.14	54.71	4.57	1.38

Note. Negative differences indicate a decrease in RMARS score; positive differences indicate an increase.
*$p < .05$.

III. CORRELATIONAL ANALYSIS OF THE RMARS

Pearson product moment coefficients of correlation were calculated to determine the relationships between mathematics anxiety, as measured by the RMARS, and (1) mathematics background, (2) mathematics achievement, (3) mathematics performance, and (4) mathematics avoidance, as previously defined. Tables 10, 11 and 12 show the means for each of these four possible correlates for each group as a whole, for the males in each group, and for the females in each group.

Hypothesis Tested by the Correlational Analysis

The null hypothesis tested was:

H_o6: The correlation coefficients are equal to zero.

Correlation coefficients were not calculated for groups with less than three members. This affected correlations for both males only and for females only. For the males, correlation coefficients were not calculated for the Elementary Education (Undergraduate) Group, the General Education Group and the Elementary Education (Graduate) Group due to group size ($n < 3$). For the females, correlation coefficients were not calculated for the Technical Group due to group size ($n < 3$).

The lack of ACT scores for graduate students prevented calculation of correlation coefficients in mathematics

TABLE 10

MEANS OF THE FACTORS SHOWN IN THE TABLE
FOR THE GROUPS SHOWN

	FACTOR			
GROUP	BACKGROUND	ACHIEVEMENT	PERFORMANCE	AVOIDANCE
CONTROL	4.73	17.20	--[a]	22.13
TECH	7.32	22.00	2.16	7.00
NONTECH	4.78	19.87	2.63	11.09
ELEM ED(U)	6.26	18.68	3.18	6.66
ELEM ED(G)	3.67	--[b]	3.67	186.50
MATH ED	13.50	23.00	3.38	4.75
GENERAL ED	5.43	19.00	3.29	84.57

Note. Background ranged from 1 course to 21 courses. Achievement ranged from 1 to 31. Performance ranged from 0.0 (F) to 4.0 (A). Avoidance ranged from 2 months to 272 months (approximately 22.5 years).
[a]No measure of mathematics performance was available for the Control Group. (No mathematics-related courses).
[b]No measure of mathematics achievement was available for graduate students. (No ACT scores).

TABLE 11

MEANS OF THE FACTORS SHOWN IN THE TABLE
FOR MALES IN THE GROUPS SHOWN

	FACTOR			
GROUP	BACKGROUND	ACHIEVEMENT	PERFORMANCE	AVOIDANCE
CONTROL	4.67	20.83	--[a]	33.67
TECH	6.56	22.06	2.03	6.31
NONTECH	6.50	21.00	3.25	8.25
ELEM ED(G)	4.00	--[b]	3.75	171.00
MATH ED	15.00	21.00	3.50	6.00

Note. Background ranged from 1 course to 21 courses. Achievement ranged from 11 to 31. Performance ranged from 0.0 (F) to 4.0 (A). Avoidance ranged from 2 months (previous quarter) to 240 months (about 20 years). The Elementary Education (Undergraduate) Group and the General Education Group were not included due to the low number of males (n = 1 and n = 0, respectively).
[a]No measure of mathematics performance available for the Control Group.
[b]No measure of mathematics achievement available for graduate students.

TABLE 12

MEANS OF THE FACTORS SHOWN IN THE TABLE
FOR FEMALES IN THE GROUPS SHOWN

	FACTOR			
GROUP	BACKGROUND	ACHIEVEMENT	PERFORMANCE	AVOIDANCE
CONTROL	4.78	14.78	--[a]	14.44
TECH	11.33	21.67	2.83	10.67
NONTECH	4.42	19.63	2.50	11.68
ELEM ED(U)	6.30	18.61	3.18	6.76
ELEM ED(G)	3.50	--[b]	3.63	194.25
MATH ED	12.60	24.20	3.30	4.00
GENERAL ED	5.43	19.00	3.29	84.57

Note. Background ranged from 1 course to 19 courses. Achievement ranged from 1 to 31. Performance ranged from 0.0 (F) to 4.0 (A). Avoidance ranged from 2 months (previous quarter) to 272 months (about 22.5 years).
[a]No measure of mathematics performance available for the Control Group.
[b]No measure of mathematics achievement available for graduate students.

achievement for the Elementary Education (Graduate) Group for both males and females.

Similarly, because the Control Group members were not enrolled in a mathematics-related course, no correlation coefficient was calculated for mathematics performance in that group.

Tables 13, 14 and 15 provide the correlation matrices for the groups as a whole, the males in each group and the females in each group, respectively.

Results of the Correlational Analysis

It was anticipated that mathematics anxiety would correlate positively with mathematics avoidance and negatively with mathematics background, mathematics achievement and mathematics performance. A total of 67 individual correlation coefficients were calculated, as shown in Tables 13, 14 and 15. In about 80 percent of the cases, the correlation coefficients indicated relationships which were as anticipated (positive or negative). In 14 of the 67 correlations, the indicated relationships were different from those anticipated. However, only in the Technical Group, where a positive correlation with achievement occurred, was the relationship significant.

In all other cases, the RMARS scores correlated as anticipated with the factors being investigated. In 18 of the 67 correlations, the correlation coefficient indicated

TABLE 13

CORRELATION MATRIX FOR THE FACTORS SHOWN AND MATHEMATICS ANXIETY OF THE GROUPS SHOWN

	FACTOR			
GROUP	BACKGROUND	ACHIEVEMENT	PERFORMANCE	AVOIDANCE
CONTROL	-.394 *	.027	--[a]	-.179
TECH	.011	-.142	-.183	-.104
NONTECH	-.423 **	-.382 **	-.606 **	-.022
ELEM ED(U)	-.211 **	-.181	.022	.105
ELEM ED(G)	-.303	--[b]	-.112	.688 *
MATH ED	.066	-.656 *	-.494	.829 **
GENERAL ED	-.286	-.484	-.467 *	.425 *

Note. A negative coefficients indicates a negative relationship with the level of mathematics anxiety; a positive coefficient indicates a positive relationship.
[a]No measure of mathematics performance available for the Control Group.
[b]No measure of mathematics achievement available for graduate students.
*$p < .05$. **$p < .01$.

TABLE 14

CORRELATION MATRIX FOR THE FACTORS SHOWN AND MATHEMATICS ANXIETY OF MALES IN THE GROUPS SHOWN

	FACTOR			
GROUP	BACKGROUND	ACHIEVEMENT	PERFORMANCE	AVOIDANCE
CONTROL	-.384	.017	--[a]	-.472
TECH	-.204	-.181	-.314	-.159
NONTECH	-.740	-.487	-.587	.865 *
MATH ED	-.034	-.702	-.756	.982 *

Note. Correlation coefficients were not calculated for Elementary Education (Undergraduate) Group, Elementary Education (Graduate) Group or General Education Group due to numbers of males in each (n = 1, n = 2 and n = 0, respectively).
[a]No measure of mathematics performance available for the Control Group.
*$p < .05$.

TABLE 15

CORRELATION MATRIX FOR THE FACTORS SHOWN AND MATHEMATICS ANXIETY OF FEMALES IN THE GROUPS SHOWN

	FACTOR			
GROUP	BACKGROUND	ACHIEVEMENT	PERFORMANCE	AVOIDANCE
CONTROL	-.406	-.054	--[a]	.040
TECH	-.297	.978 *	.629	.931
NONTECH	-.258	-.351 *	-.617 **	-.144
ELEM ED(U)	-.218 **	-.179	-.021	.102
ELEM ED(G)	-.294	--[b]	-.294	.582
MATH ED	.034	-.690	-.488	.765 *
GENERAL ED	-.286	-.484	-.467 *	.425 *

[a]No measure of mathematics performance available for the Control Group.
[b]No measure of mathematics achievement available for graduate students.
*$p < .05$. **$p < .01$.

that the relationship was significant ($p < .05$) and as anticipated.

Correlations with Groups, Disregarding Sex. For the groups as a whole, the RMARS scores correlated significantly ($p < .05$) and negatively with: (1) mathematics background for the Control Group, the Nontechnical Group and the Elementary Education (Undergraduate) Group; (2) mathematics achievement for the Nontechnical Group and the Mathematics Education Group; and (3) mathematics performance for the Nontechnical Group and the General Education Group.

The RMARS scores correlated significantly ($p < .05$) and positively with mathematics avoidance for the Elementary Education (Graduate) Group, the Mathematics Education Group, and the General Education Group.

Specifically, the negative relationship between RMARS scores and mathematics background seems to imply that as the level of mathematical background increased, the level of mathematics anxiety tended to decrease. Similarly, the negative correlation coefficients for mathematics achievement and mathematics performance seem to indicate that higher levels of mathematics achievement (ACT score) and mathematics performance (course grade) tended to be associated with lower levels of mathematics anxiety.

However, the significant positive correlation coefficients seem to indicate that increased avoidance of

mathematics is associated with higher levels of mathematics anxiety.

Correlations for Males. As indicated in Table 14, the RMARS scores correlated significantly ($p < .05$) and positively with mathematics avoidance for males in the Nontechnical Group and the Mathematics Education Group.

Correlations for Females. As indicated in Table 15, the RMARS correlated significantly ($p < .05$) and negatively with (1) mathematics background for females in the Elementary Education (Undergraduate) Group, (2) mathematics achievement for females in the Nontechnical Group, and (3) mathematics performance for females in the General Education Group and in the Nontechnical Group.

The RMARS scores correlated significantly ($p < .05$) and positively with mathematics avoidance for females in the Mathematics Education Group and in the General Education Group, and with mathematics achievement for females in the Technical Group.

Discussion of the Results

1. Higher levels of mathematics anxiety are associated with lower levels of mathematics background:

   (a) for the Elementary Education (Undergraduate) Group as a whole and for the females within the Elementary Education (Undergraduate) Group,

   (b) for the Control Group as a whole, and

(c) for the Nontechnical Group as a whole.

2. Higher levels of mathematics anxiety are associated with lower mathematics achievement:

(a) for the Nontechnical Group as a whole, and for the female members of the Nontechnical Group; and

(b) for the Mathematics Education Group as a whole.

3. Higher levels of mathematics anxiety are associated with lower mathematics performance:

(a) for the Nontechnical Group as a whole and for the females within the Nontechnical Group; and

(b) for the General Education Group as a whole and for the females within the General Education Group.

4. Higher levels of mathematics anxiety are associated with higher levels of mathematics avoidance:

(a) for the entire Mathematics Education Group (males, females and as a whole);

(b) for the General Education Group as a whole and for the females within the General Education Group;

(c) for the Elementary Education Group (Graduate) as a whole; and

(d) for the males in the Nontechnical Group.

IV. SUMMARY

This chapter presents and discusses the results of the analysis of the Revised Mathematics Anxiety Rating Scale, the changes in RMARS scores between pretest and posttest, and the correlation coefficients for the factors of mathematics background, mathematics achievement, mathematics performance and mathematics avoidance.

CHAPTER V

SUMMARY, CONCLUSIONS, AND SUGGESTIONS

The purpose of this study was to investigate the prevalence and intensity of mathematics anxiety in college students and preservice teachers, to determine factors which are related to the occurrence of mathematics anxiety in college students and preservice teachers, and to determine whether success in a mathematics or a mathematics methods course reduces mathematics anxiety. In order to accomplish this, data were gathered from students enrolled in mathematics, education and English classrooms. The primary sources for these data were two instruments which were completed by the students:

1. the revised version of the Mathematics Anxiety Rating Scale (RMARS), which was used to provide a measure of mathematics anxiety, and

2. the Student Information Sheet (SIS), which solicited information from the student that could be used to determine sex, college major, age, mathematics background, and mathematics avoidance.

In addition, each participant signed a consent form which allowed the investigator to obtain, from the

university administration, data concerning mathematics achievement and mathematics performance in the current mathematics-related course.

I. ANSWERS TO RESEARCH QUESTIONS

In their report of their development and validation of the RMARS, Plake and Parker (1982) reported the mean RMARS score of a college population to be 59.84. The mean RMARS score for all participants in the current study was 55.30. The mean scores of two of the seven groups in the study exceeded the normative mean: the Control Group and the Elementary Education (Graduate) Group, with mean RMARS scores of 65.33 and 62.33, respectively. The mean scores of the remaining five groups were all below the normative mean. The Technical Group mean of 46.21 was the lowest of any group.

Although the Control Group mean was above the normative mean, about half (8 of 15) of the students in the group had scores above the normative mean and about half (7 of 15) had scores below the normative mean. Of the other 110 participants, only 36 (about 33%) had RMARS scores which exceeded the normative mean. The Elementary Education (Graduate) Group was the only other group in which more than half of the students in the group (5 of 6) exceeded the normative mean.

In summary, it appears that the prevalence and

intensity of mathematics anxiety among the subjects in this study was relatively low, compared to other college populations.

The pretest RMARS scores of about 22% of the males in the study and about 40% of the females exceeded the normative mean RMARS score. Pretest scores ranged from 44 to 95 for the Control Group, from 26 to 95 for the males in the study and from 26 to 100 for the females in the study. The mean pretest RMARS score for all males participating in the study was 50.75. For females, the mean pretest RMARS score was 56.87. The two-way analysis of variance of RMARS scores indicated no significant differences in the levels of mathematics anxiety between males and females.

Ninety-eight of 110 students successfully completed the mathematics-related course in which they were enrolled. For these students, the t-test for paired samples was used to test the difference, if any, between their pretest and posttest RMARS scores. For all groups, these tests indicated no significant decrease in mathematics anxiety.

The only decrease in mathematics anxiety as measured by the RMARS occurred in the Elementary Education (Undergraduate) Group. However, even this decrease was not at a significant level. Throughout the study, the level of mathematics anxiety routinely increased from pretest to posttest, although the increases were not generally

statistically significant. The only significant ($p < .05$) difference between pretest and posttest scores was an increase in mathematics anxiety in the Nontechnical Group.

The t-test for paired samples was also applied to the group of 12 participants who did not successfully complete the mathematics-related course in which they were enrolled. As a group, their mean RMARS score also increased, but the difference was not statistically significant.

In summary, mathematics anxiety was not decreased significantly by successful completion of a mathematics-related course, nor was it increased by failure of the course. It appears that, at least in the short term, mathematics anxiety is not affected by success or failure in one mathematics-related class.

The results suggest several factors which are related to mathematics anxiety, however:

1. The two-way analysis of variance and the subsequent pair-wise comparisons indicated that mathematics anxiety is related to college major. The mathematics anxiety of the Technical Group was the lowest among the seven groups, followed in order by the Mathematics Education Group, the General Education Group and the Nontechnical Group. The groups with the highest mathematics anxiety were the Control Group (not enrolled in any mathematics-related course) and the two Elementary Education Groups (Graduate and Undergraduate, in descending order). Seven of the 21 pair-

wise tests were significant ($p < .05$) and all seven involved one of these three groups with the highest levels of mathematics anxiety.

2. The results of the two-way analysis of variance indicated no significant differences in the level of mathematics anxiety reported by males and females. Thus, it seems that mathematics anxiety is not related to sex differences.

3. Mathematics anxiety is significantly related to mathematics background in the Control Group ($p < .05$); the Elementary Education (Undergraduate) Group ($p < .01$) and the females within that group ($p < .01$); and the Nontechnical Group ($p < .01$). The negative correlation coefficients indicate a negative relationship such that the fewer mathematics courses a student has successfully completed (lower background), the higher the level of mathematics anxiety is likely to be.

4. Mathematics anxiety is significantly related to mathematics achievement for the Nontechnical Group ($p < .01$), the females within that Group ($p < .05$) and the Mathematics Education Group ($p < .05$). The negative correlation coefficients indicate a negative relationship which seems to imply that students with higher ACT mathematics scores are likely to encounter lower levels of mathematics anxiety than students with lower ACT scores.

5. Mathematics anxiety is significantly related to mathematics performance for both the Nontechnical Group ($p < .01$), for the females ($p < .01$) in that group, and for the General Education Group ($p < .05$). The negative correlation coefficient means that the high mathematics anxiety tends to be associated with low mathematics performance.

6. Mathematics anxiety is significantly related to mathematics avoidance in the Mathematics Education Group as a whole ($p < .01$), and in both the males ($p < .05$) and the females ($p < .05$) in that group; the General Education Group ($p < .05$) and the female members in that group ($p < .05$); and the Elementary Education (Graduate) Group ($p < .05$). The positive correlation coefficient means that a high level of mathematics anxiety is likely to be associated with higher levels of mathematics avoidance.

II. CONCLUSIONS

Mathematics anxiety showed a moderate relationship to all four of the factors being investigated: mathematics background, mathematics achievement, mathematics performance and mathematics avoidance.

1. Of the 17 correlation coefficients calculated to investigate the relationship between mathematics background and mathematics anxiety, only three indicated that the relationship was positive. Four of the remaining 15 negative correlation coefficients were significant; three at the

($p < .01$) level and one at the ($p < .05$) level, seeming to indicate a moderately strong negative relationship.

2. For the correlations between mathematics achievement and mathematics anxiety, 15 correlation coefficients were calculated. Thirteen of these 15 indicate that a negative relationship exists. Two of these negativecorrelation coefficients are significant at the ($p < .01$) level and one at the ($p < .05$) level. Neither of the positive coefficients is significant. This seems to indicate that a moderately strong negative relationship exists between mathematics achievement and mathematics anxiety.

3. To investigate the relationship between mathematics anxiety and mathematics performance, 14 correlation coefficients were calculated. Only one of these indicates a positive relationship and it is not significant. The other thirteen coefficients include two which are significant at the ($p < .01$) level and two which are significant at the ($p < .05$) level. This seems to indicate that a strong negative relationship exists between mathematics anxiety and mathematics performance.

4. Eighteen correlation coefficients were calculated for the comparisons of mathematics anxiety and mathematics avoidance. Of these, six coefficients (none statistically significant) indicate a negative relationship. The other

twelve indicate a positive correlation between mathematics avoidance and mathematics anxiety. Six of these positive correlation coefficients are significant at the ($p < .05$) level and one at the ($p < .01$) level. This suggests a strong positive correlation exists between mathematics avoidance and mathematics anxiety.

5. Overall, students majoring in the more rigorous and mathematically demanding areas such as the Technical Group and the Mathematics Education Group seemed to exhibit less mathematics anxiety than did students from other majors.

6. No sex-related differences in mathematics anxiety were found during this study, although there were definite sex-related differences in the numbers of males and females enrolled in each major area. The Technical Group, made up of 16 males and 3 females, was the only group which was predominantly male. The Elementary Education (Undergraduate) Group, made up of 1 male and 46 females, the General Education Group, made up of 7 females and no males, and the Nontechnical Group, made up of 4 males and 19 females, were predominantly female.

This absence of females among the technical majors and the dominance of females in the education areas, and in particular in the area of elementary education, is not unusual in the literature.

III. SUGGESTIONS FOR FURTHER RESEARCH

Although various movements and social forces have had some effect on female enrollments in mathematics in recent years, continuing disparities are found between male and female enrollments in technical areas of study such as engineeering, the physical sciences and mathematics. In this study, males and females did not differ significantly in the levels of mathematics anxiety they reported, but there were sex differences noted in their patterns of enrollment in certain areas and there are other factors which should also be investigated. In an increasingly competitive and technological world, our society cannot afford to have one half of its population avoiding the more rigorous and mathematically demanding areas of study, for any reason.

In this study, as in many other studies, students majoring in elementary education were found to have high levels of mathematics anxiety. These high levels of mathematics anxiety do not seem to be attributable to higher requirements since the mathematics requirements in most elementary education curricula are minimal. Rather, this would seem to indicate that students with high levels of mathematics anxiety may be attracted to elementary education as a major. Additional research is needed to investigate both the causes and the consequences of

mathematics anxiety, particularly in the area of elementary education and mathematics teachers.

Some type of longitudinal study is needed which would monitor the level of mathematics anxiety of both students and teachers to investigate the claim made by some researchers that mathematics anxiety can be transmitted in the classroom by teachers who are, themselves, mathematics-anxious.

Because of the debilitating nature of mathematics anxiety, additional investigation is needed to explore preventative measures which can prevent the development of mathematics anxiety and to explore effective means of remediating the effects of mathematics anxiety once it has developed.

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APPENDICES

APPENDIX A

MATERIALS USED

PRETEST BRIEF

THIS CLASS HAS BEEN SELECTED TO PARTICIPATE IN A RESEARCH PROJECT DEALING WITH MATHEMATICS ANXIETY. THIS PROJECT HAS BEEN APPROVED BY BOTH THE UNIVERSITY AND THE DEPARTMENT. HOWEVER, PARTICIPATION IS NOT MANDATORY. NONPARTICIPATION WILL NOT AFFECT YOUR GRADE IN ANY WAY. WE HOPE, OF COURSE, THAT YOU WILL CHOOSE TO PARTICIPATE.

NO STUDENT (OR INSTRUCTOR) WILL BE IDENTIFIED IN ANY WAY IN REPORTING THE RESULTS OF THIS RESEARCH. PARTICIPANTS WILL BE ASKED TO SIGN A CONSENT FORM WHICH AUTHORIZES THE UNIVERSITY TO RELEASE TO THE RESEARCHER YOUR SCORE ON THE MATHEMATICS SUBTEST OF THE ACT AND (IF THIS IS A MATH-RELATED COURSE) YOUR GRADE IN THIS COURSE. ALL STUDENT DATA WILL BE HELD IN STRICT CONFIDENCE BY THE RESEARCHER.

PARTICIPANTS WILL BE ASKED TO COMPLETE A SHEET OUTLINING YOUR PREVIOUS MATHEMATICS BACKGROUND, AND TO COMPLETE A TWO-PAGE SCALE ON WHICH YOU ESTIMATE THE AMOUNT OF ANXIETY YOU WOULD FEEL IN VARIOUS MATHEMATICAL SITUATIONS. THERE ARE NO MATHEMATICAL SKILLS REQUIRED AND THE ENTIRE PROCEDURE WILL COST YOU ONLY ABOUT TWENTY MINUTES OF YOUR TIME NOW - AND PERHAPS TEN MINUTES NEAR THE END OF THE QUARTER.

IF YOU CHOOSE NOT TO PARTICIPATE IN THE STUDY - OR IF YOU ARE NOT EIGHTEEN YEARS OLD - THEN PLEASE JUST COMPLETE THE STUDENT INFORMATION SHEET FOR ME AND RETURN THE OTHER FORM UNMARKED SO THAT IT CAN BE RE-USED.

PLEASE ANSWER EVERY QUESTION TO THE BEST OF YOUR ABILITY AND PLEASE NOTE THAT THE LAST FORM HAS BOTH A FRONT AND A BACK SIDE TO BE FILLED OUT.

THANK YOU FOR YOUR COOPERATION AND INDULGENCE.

CONSENT FORM
for

MATHEMATICS ANXIETY RESEARCH PROJECT
UNIVERSITY OF TENNESSEE, KNOXVILLE

During the Winter Quarter, 1987, members of certain pre-selected classes at the University of Tennessee, Knoxville will have the opportunity to participate in a current research study dealing with mathematics anxiety.

Participation requires completion of this form, a brief student information sheet and a scale called the revised Mathematics Anxiety Rating Scale (RMARS). The RMARS requires no complex mathematical skills. It briefly describes twenty-four mathematics-related situations. Participants are then asked to state how anxious they would feel in that situation.

By participating in the study, each person also authorizes The University of Tennessee to release his or her ACT Mathematics subtest score and course grade for the current mathematics course to the researcher. All data will be held in confidence by the researcher and no student will be identified in any way in the publication of the research.

It seems reasonable to assume that participants will not experience any negative effects from participation in the study and it is possible that participation might provide some insight into one's own attitudes and feelings about mathematics.

Participation is on a voluntary basis and will have no effect on any course grade. There is no penalty for choosing not to participate, either now or later in the quarter. We hope, however, that you will choose to join in our research effort by consenting to participate. If you have any questions regarding the study, please contact Bob Coleman at 573-0524.

I have read the explanation provided above and I consent to participate in the research study.

NAME :_____

SOCIAL SECURITY NUMBER :_____

DATE :_____

Please check the appropriate blank below:

I am 18 years of age or older _____

I am under 18 years of age _____

STUDENT INFORMATION SHEET

Please complete the following statements about yourself:

NAME : _____(please print)
last first middle

SEX: male _____ female _____ CURRENT AGE: _____ (yrs)

SOC.SEC.NO.: _____ MAJOR: (*)_____

(*) If your major is education, please check ONE block below:

MATH EDUCATION_____ SECONDARY / VTE / HIGHER ED_____
ELEMENTARY ED_____

****

List any mathematics courses or mathematics methods courses you are taking THIS QUARTER: (Do NOT include THIS class.)

1._____

2._____

****

Place a check beside EACH mathematics course you have completed with a grade of `C' or better:

A. PRIOR to college	B. IN college	
_____ GENERAL MATH	MATH 0100-20 (HS ALGEBRA)	_____
_____ ALGEBRA I	MATH 0130-40 (GEOMETRY)	_____
_____ GEOMETRY	MATH 0150 (TRIGONOMETRY)	_____
_____ ALGEBRA II	MATH 1140 (BAS.MATH SKLS)	_____
_____ TRIGONOMETRY	MATH 2110-30 (STR NUM SYS)	_____
_____ ANALYSIS	MATH 1540 (COLL. ALGEBRA)	_____
_____ PRECALCULUS	MATH 1700 (PRECALCULUS)	_____
_____ ADVANCED MATH	MATH 1840 (CALCULUS)	_____
_____ CALCULUS	OTHER (SPECIFY)	_____

****

List the date you LAST completed a math course with a grade of `C' or better:

(mo/yr)_____/_____

****

Have you ever participated in any kind of a mathematics anxiety treatment program?

NO_____ YES_____

Are you repeating this course because of a previous `D' or `F'?

NO_____ YES_____

REVISED MATHEMATICS ANXIETY RATING SCALE (RMARS)

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

	Not at all	A little	A fair amount	Much	Very much
Buying a math textbook.	☐	☐	☐	☐	☐
Watching a teacher work an algebraic equation on the blackboard.	☐	☐	☐	☐	☐
Signing up for a course in Statistics.	☐	☐	☐	☐	☐
Listening to another student explain a math formula.	☐	☐	☐	☐	☐
Walking into a math class.	☐	☐	☐	☐	☐
Looking through the pages of a math text.	☐	☐	☐	☐	☐
Starting a new chapter in a math book.	☐	☐	☐	☐	☐
Walking on campus and thinking about a math course.	☐	☐	☐	☐	☐
Reading the word "Statistics".	☐	☐	☐	☐	☐
Solving a square root problem.	☐	☐	☐	☐	☐
Reading and interpreting graphs or charts.	☐	☐	☐	☐	☐
Thinking about an upcoming math test one day before.	☐	☐	☐	☐	☐

	Not at all	A little	A fair amount	Much	Very Much
Reading a formula in chemistry	☐	☐	☐	☐	☐
Taking an examination (quiz) in a math course.	☐	☐	☐	☐	☐
Taking an examination (final) in a math course.	☐	☐	☐	☐	☐
Working on an abstract mathematical problem, such as: "If x=outstanding bills, and y=total income, calculate how much you have left for recreational expenditures."	☐	☐	☐	☐	☐
Picking up the math text book to begin working on a homework assignment.	☐	☐	☐	☐	☐
Being given a homework assignment of many difficult problems which is due the next class meeting.	☐	☐	☐	☐	☐
Waiting to get a math test returned in which you expected to do well.	☐	☐	☐	☐	☐
Getting ready to study for a math test.	☐	☐	☐	☐	☐
Listening to a lecture in a math class.	☐	☐	☐	☐	☐
Being given a "pop" quiz in a math class.	☐	☐	☐	☐	☐
Having to use tables in the back of a math book.	☐	☐	☐	☐	☐
Being told how to interpret probability statements.	☐	☐	☐	☐	☐

APPENDIX B

STATISTICAL DATA

TABLE B-1

STATISTICAL DATA -- CONTROL GROUP (n = 15)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH AVOIDANCE
M	75	75	3	16	23
M	95	102	5	25	2
M	44	40	10	30	62
M	82	82	3	22	57
M	54	49	1	11	56
M	58	72	6	21	2
F	76	91	2	1	2
F	45	45	7	26	2
F	73	68	4	27	2
F	59	80	3	11	21
F	53	58	6	16	2
F	60	62	10	18	11
F	63	63	3	4	44
F	92	97	4	20	20
F	51	49	4	10	26

TABLE B-2

STATISTICAL DATA -- TECHNICAL GROUP (n = 19)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH PERFORMANCE	MATH AVOIDANCE
M	66	80	7	25	2.0	2
M	45	54	6	28	1.0	2
M	32	32	9	20	3.5	2
M	38	34	6	19	2.0	3
M	51	62	7	19	1.0	2
M	57	50	3	16	1.0	10
M	35	34	8	23	3.5	56
M	43	55	10	16	2.0	2
M	45	44	5	20	1.0	2
M	37	50	6	31	0.0	7
M	37	45	7	24	4.0	2
M	33	43	5	22	3.0	2
M	84	77	6	21	2.0	3
M	42	45	6	23	2.0	2
M	45	37	8	21	2.0	2
M	30	35	6	25	2.5	2
F	51	47	6	18	1.0	9
F	56	55	9	27	4.0	21
F	51	44	19	20	3.5	2

TABLE B-3

STATISTICAL DATA -- NONTECHNICAL GROUP (n = 23)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH PERFORMANCE	MATH AVOIDANCE
M	50	47	4	20	3.5	8
M	64	65	6	17	3.0	21
M	44	48	6	26	3.0	2
M	26	32	10	21	3.5	2
F	49	48	8	27	3.0	2
F	55	75	4	24	3.0	9
F	62	68	5	23	2.0	2
F	75	59	4	17	0.0	14
F	45	44	3	20	3.0	20
F	60	56	5	23	3.0	8
F	38	32	7	17	3.0	2
F	49	66	7	18	2.0	2
F	49	72	4	27	3.5	8
F	41	50	6	19	3.0	2
F	63	68	4	23	0.0	3
F	51	75	4	15	3.0	33
F	61	77	2	12	3.5	2
F	54	56	2	23	3.0	68
F	29	37	4	19	3.0	20
F	41	36	3	23	4.0	9
F	84	89	3	14	0.0	2
F	63	61	4	17	2.0	14
F	73	75	5	12	3.5	2

TABLE B-4

STATISTICAL DATA -- ELEMENTARY EDUCATION (UNDERGRADUATE) GROUP (n = 47)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH PERFORMANCE	MATH AVOIDANCE
M	54	59	4	22	3.0	2
F	65	72	4	5	4.0	18
F	54	48	9	20	4.0	8
F	48	38	6	16	4.0	2
F	52	63	2	12	3.0	2
F	49	53	5	21	3.5	20
F	65	56	9	24	3.5	2
F	59	34	5	7	3.5	2
F	80	68	5	21	2.0	26
F	59	52	6	21	4.0	2
F	81	65	11	10	3.0	2
F	68	76	6	21	3.0	2
F	31	29	6	26	4.0	2
F	97	97	7	14	4.0	8
F	76	61	8	7	2.5	5
F	63	65	2	4	1.0	2
F	48	62	3	14	3.0	2
F	53	60	8	14	3.0	8
F	32	31	6	15	3.0	2
F	46	42	8	27	4.0	9
F	32	35	11	28	4.0	2
F	64	56	6	27	4.0	20
F	79	80	4	16	0.0	2

TABLE B-4 (continued)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH PERFORMANCE	MATH AVOIDANCE
F	36	31	8	21	4.0	11
F	53	51	5	19	3.0	2
F	63	81	9	22	2.5	2
F	26	32	13	22	3.0	11
F	52	51	3	22	3.0	20
F	60	54	3	19	4.0	8
F	73	73	6	19	4.0	8
F	51	36	7	18	2.0	8
F	43	56	5	25	4.0	2
F	90	81	4	21	3.5	2
F	32	39	10	14	0.0	2
F	44	52	5	13	3.0	2
F	81	55	7	24	4.0	2
F	71	66	3	16	3.0	2
F	55	49	10	26	3.5	20
F	37	36	6	25	4.0	2
F	38	49	6	15	2.0	2
F	51	53	10	24	4.0	20
F	56	58	5	23	2.0	2
F	100	99	7	23	4.0	11
F	52	46	8	25	4.0	6
F	62	61	3	10	2.5	2
F	68	77	4	19	3.5	2
F	72	74	6	21	4.0	14

TABLE B-5

STATISTICAL DATA -- ELEMENTARY EDUCATION (GRADUATE) GROUP ($\underline{n}$ = 6)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH PERFORMANCE	MATH AVOIDANCE
M	44	45	4	3.5	102
M	64	73	4	4.0	240
F	62	70	5	4.0	246
F	54	37	5	4.0	80
F	62	73	1	3.0	215
F	88	90	3	3.5	236

TABLE B-6

STATISTICAL DATA -- MATHEMATICS EDUCATION GROUP (n = 8)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH PERFORMANCE	MATH AVOIDANCE
M	41	38	14	26	4.0	2
M	56	66	10	12	3.5	8
M	53	54	21	25	3.0	8
F	50	38	12	23	3.0	6
F	45	42	7	21	2.5	2
F	58	64	17	24	3.0	8
F	48	60	11	22	4.0	2
F	32	34	16	31	4.0	2

TABLE B-7

STATISTICAL DATA -- GENERAL EDUCATION GROUP (n = 7)

SEX	RMARS PRETEST	RMARS POSTTEST	MATH BACKGROUND	MATH ACHIEVEMENT	MATH PERFORMANCE	MATH AVOIDANCE
F	52	48	7	--	3.0	85
F	41	38	12	25	4.0	2
F	53	66	5	--	4.0	272
F	59	72	4	15	2.0	2
F	37	33	4	--	4.0	59
F	73	75	3	--	3.0	152
F	36	51	3	17	3.0	20

Note: Four graduate students had no ACT scores.

APPENDIX C

HUMAN SUBJECTS APPROVAL

THE UNIVERSITY OF TENNESSEE
KNOXVILLE

Office of
Research
Compliances

January 14, 1987

Mr. Bobby L. Coleman
305 E. Lake Forest Drive
Knoxville, TN 37920

Dr. D. J. Dessart
218-C Claxton Education Bldg.
CAMPUS

Dear Mr. Coleman and Dr. Dessart:

The project which you submitted entitled, "The Prevalanence and Intensity of Mathematics Anxiety in College Students and Preservice Teachers at a Large Southern University," CRP #2253-A, has been reviewed and certified exempt from review by the Committee on Research Participation.

This certification is for a period ending January 14, 1988. Please make timely submission of renewal or prompt notification of project termination (see item #2 below).

The responsibility of the project director includes the following:

1. Prior approval from the Director of Research Compliances must be obtained before any changes in the project are instituted.

2. A statement must be submitted (Form D) at 12-month intervals attesting to the current status of the project (protocol is still in effect, project is terminated, etc.).

The Committee wishes you success in your research endeavors.

Sincerely,

L. B. Cebik, Director

cc: Dr. Thomas C. Collins, Vice Provost for Research

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VITA

Bobby Leon Coleman was born in Knoxville, Tennessee on November 14, 1937. He graduated from Knoxville South High School in 1955, and attended Carson-Newman College for one year prior to enlisting in the U. S. Marine Corps.

In 1958, he was one of the first 32 Marines selected to receive a Naval Enlisted Scientific Education Program (NESEP) scholarship. Through this program, he was graduated from Vanderbilt University in 1961 with a Bachelor of Arts degree in Mathematics and was commissioned as a Marine Officer. He served as a jet attack pilot from 1961 to 1981, completing two tours in Vietnam, 3000 flight hours and 332 combat missions before retiring in 1981 as a Lieutenant Colonel. His military awards include the Distinguished Flying Cross and the Air Medal.

In 1983, he entered the Graduate School of The University of Tennessee. He received the Master of Science degree in Mathematics Education in May, 1985, and the Doctor of Philosophy degree in Education in August, 1991.

Bob married his high school sweetheart, the former Emma Lou Ott of Rockford, Tennessee, in 1956. They have three daughters and six grandchildren. He is a member of Pi Lambda Theta honorary society, the National Council of Teachers of Mathematics, the Tennessee Mathematics Teachers Association and the Smoky Mountain Mathematics Educators Association.