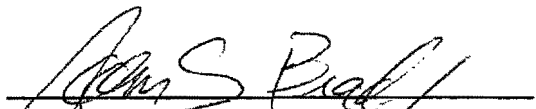
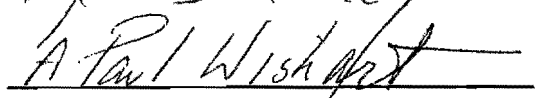
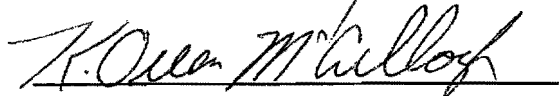


To the Graduate Council:

I am submitting herewith a dissertation written by Patricia Ann Preston entitled "Math Anxiety: Relationship with Sex, College Major, Mathematics Background, Mathematics Achievement, Mathematics Performance, Mathematics Avoidance, Self-rating of Mathematics Ability, and Self-rating of Mathematics Anxiety as Measured by the Revised Mathematics Anxiety Rating Scale (RMARS)." 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.


Donald J. Messart, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:


Vice Provost
and Dean of The Graduate School

MATH ANXIETY: RELATIONSHIP WITH SEX, COLLEGE MAJOR, MATHEMATICS
BACKGROUND, MATHEMATICS ACHIEVEMENT, MATHEMATICS PERFORMANCE,
MATHEMATICS AVOIDANCE, SELF-RATING OF MATHEMATICS ABILITY,
AND SELF-RATING OF MATHEMATICS ANXIETY AS MEASURED BY
THE REVISED MATHEMATICS ANXIETY RATING SCALE (RMARS)

A Dissertation.

Presented for the
Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Patricia Ann Preston

June 1986

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DEDICATION

To my mom and dad

ACKNOWLEDGMENTS

Many people have contributed to making this dissertation possible. I am especially indebted to Donald Dessart, the chairman of my doctoral committee. Special thanks are due John Bradley, Ken McCullough, Paul Wishart, Carl Murphy, and Alan Lasater, members of my committee.

A particular note of appreciation is due the instructors and administrators of the study, and the entire staff of the Mathematics Department.

I am grateful to Lisa Hunt and especially Michael Keene for all their suggestions and editing and to Ann LaCava of the Graduate School for all her assistance.

But most of all I thank my husband, our children and their grandparents for all their support and sacrifice through the years.

ABSTRACT

Mathematics educators and psychologists blame "math anxiety" for affecting mathematics learning, performance, and enrollment, and, subsequently, choice of college major and career. Researchers have yet to agree on the prevalence, stability, and effects of math anxiety.

This study (1) investigated the prevalence and intensity of math anxiety in college students (as a whole, by major, and by sex), (2) determined the stability of math anxiety over time, and (3) investigated those background and experiential factors related to its occurrence in college students, using data gathered on 173 college students in mathematics, education, and English classrooms. The data concerned college students' math anxiety as measured by the Revised Mathematics Anxiety Rating Scale (RMARS) and selected cognitive correlates of math anxiety, and were analyzed by analyses of variance, t-tests, and correlational analyses.

Based upon the statistical analyses, these results were achieved: (1) math anxiety is related to choice of college major, (2) males and females do not differ in math anxiety levels, (3) math anxiety levels change little over a short time interval, (4) math anxiety shows relatively little relationship to mathematics performance, (5) math anxiety shows a moderate relationship to mathematics background, achievement, and avoidance, and (6) the higher one's level of math anxiety (as measured by the RMARS), the lower one's self-rating of mathematics ability and the higher one's self-rating of mathematics anxiety.

Based upon the results, these conclusions were drawn: (1) improving mathematics performance will require programs that do more than reduce math anxiety, (2) re-entry students would appear to benefit most from treatment of math anxiety, (3) math anxiety appears to be related to inherent mathematical abilities of students, (4) the RMARS seems to adequately measure one's level of math anxiety as perceived by oneself for all groups except for the Technical Majors enrolled in Precalculus Mathematics, (5) sex-related differences in math anxiety may exist, but are probably much smaller than suggested previously, and (6) the reduction of math anxiety in the Technical Majors Groups could be attributed primarily to the unique elements of these groups: course content, prerequisites, and position in the sequence.

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CHAPTER I

INTRODUCTION

Mathematical skills are essential to any person's success in technical fields, as well as in the nontechnical fields of education, business, social and behavioral sciences, the humanities, and the arts. Additionally, mathematical skills are needed for personal life; we use mathematics for such routine activities as checkbook balancing, computer billing, filing income tax returns, tipping, interpreting charts and graphs, and budgeting.

Despite the importance of mathematical skills in educational, occupational, and routine activities, many students perform poorly in mathematics courses or avoid taking mathematics courses in high school and college, thus limiting their choice of careers to those which do not require mathematical skills (Betz, 1978).

The problems of poor performance in mathematics courses and mathematics-course avoidance have been identified as being particularly apparent among women. Fox, Fennema, and Sherman (1977) and Maccoby and Jacklin (1974) found that women in secondary school mathematics courses did not perform as well as men.

Studying the high school backgrounds of freshmen entering the University of California-Berkeley in 1972, Sells (1978) found the incidence of mathematics-course avoidance much higher for females than for males. Only 43% of the males had not completed a second year of algebra and a precalculus course, compared to 92% of the females. Ernest

(1976) found a pattern of high school mathematics-course avoidance among females similar to that found by Sells. His random sample of 50 males and 50 females at the University of California-Santa Barbara indicated that 64% of the males, compared to 84% of the females, had not completed four years of high school mathematics. Fennema and Sherman (1976) found that an increasing number of intellectually capable students, especially females, failed to enroll in high school mathematics courses beyond those required.

One important affective variable used to explain both mathematics-course avoidance and poor mathematics performance is "math anxiety" (Betz, 1978; Tobias, 1978; Aiken, 1976; Richardson and Suinn, 1972; Gough, 1954). Math anxiety is frequently referred to as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson and Suinn, 1972, p. 551).

Gough identified "mathemaphobia" as a major cause of failure in mathematics (Gough, 1954). She found students afflicted with mathemaphobia in elementary school, junior high school, high school, and college. She concluded that once mathematics courses become optional, mathemaphobia causes the enrollment in these courses to be relatively low.

More recently, Suinn, Edie, Nicoletti, and Spinelli (1972, p. 373) reported that roughly 28% of 397 undergraduates surveyed "exhibited extreme levels of tension associated with mathematics situations or number manipulations." Richardson and Suinn (1972) stated that

mathematics anxiety may prevent a student from passing fundamental mathematics courses or prevent his pursuing advanced courses in mathematics or the sciences. We have found that a number of volunteers for mathematics anxiety treatment are graduate students who have difficulty with the small but significant number of mathematical formulations in their area of specialization, such as zoology or business. (p. 551)

Math anxiety is believed to be more prevalent in women (Tobias, 1978; Fox, Fennema, and Sherman, 1977) causing among them a lower rate of enrollment in mathematics courses. As a result, women frequently cannot enter into many fields because they lack mathematics prerequisites, resulting in unequal educational and employment opportunities for them.

In summary, math anxiety has engendered much interest in both the professional and popular literature. Mathematics educators and psychologists have associated math anxiety with both mathematics-course avoidance and poor mathematics performance. Mathematics-course avoidance and poor mathematics performance result in the failure to attain new mathematical skills and the degeneration of previous skills. Thus, math anxiety affects mathematics performance and enrollment, and, subsequently, choice of college major and career, particularly for women.

I. STATEMENT OF THE PURPOSE

The purpose of this study was to investigate the prevalence and intensity of math anxiety in college students (as a whole, by major, and by sex), to determine the stability of math anxiety over time, and to determine those background and experiential factors related to the occurrence of math anxiety in college students. This purpose was accomplished by using data gathered on college students in mathematics, education, and English classrooms; analyzed by an analysis of variance, t-tests, and a correlational analysis. The data concerned college students' math anxiety and selected cognitive correlates of math anxiety.

II. RESEARCH QUESTIONS

To identify (1) the prevalence and intensity of math anxiety in a college population, (2) the stability of math anxiety over time, and (3)

the background and experiential factors influencing the occurrence and stability of math anxiety, the study posited several specific questions:

1. Is math anxiety related to choice of college major?
2. Do females and males differ in their math anxiety levels?
3. Do math anxiety levels change over a short time interval?
4. Is math anxiety related to
 - (a) mathematics background: highest level of mathematics course successfully completed?
 - (b) mathematics achievement: score on the ACT mathematics subtest?
 - (c) mathematics performance: grade received in current mathematics-related course?
 - (d) mathematics avoidance: lapse of time since last successfully completed mathematics course?
 - (e) self-rating of mathematics ability?
 - (f) self-rating of mathematics anxiety?

III. DEFINITIONS OF TERMS

The following definitions of terms are used in this study:

1. Math 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 Plake and Parker's (1982) revised version of the Mathematics Anxiety Rating Scale (RMARS).

2. Mathematics background is the highest level of mathematics course successfully completed.

3. Mathematics achievement is the score on the ACT mathematics subtest.

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

5. Mathematics avoidance is the lapse of time since last successfully completed mathematics course.

6. The Nontechnical Majors Group is composed of students majoring in accounting, advertising, agriculture, broadcasting, home economics, human services, management, marketing, nursing, physical therapy, political science, and psychology. They were enrolled in Mathematics 1540--College Algebra.

7. The Technical Majors Group is composed of students majoring in architecture, biology, chemistry, computer science, engineering, geology, mathematics, and physics. These students were enrolled in Mathematics 1700--Precalculus or Mathematics 1840--Single Variable Calculus.

8. The Elementary Education Majors Group is composed of students majoring in elementary education. They were enrolled in Mathematics 2110, 2120, or 2130--Structure of the Number System.

9. The Mathematics Education Majors Group is composed of students majoring in mathematics education. They were enrolled in Curriculum and Instruction 3752--Teaching of Mathematics: Geometry and Analysis, Grades 7 - 12.

10. The Graduate Students Group is composed of graduate students majoring in educational fields. They were enrolled in Curriculum and Instruction 5610--Educational Statistics.

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

IV. METHOD

During Winter Quarter, 1985, at The University of Tennessee, Knoxville, data were collected from students enrolled in the following lecture courses:

1. Mathematics 1540, College Algebra;
2. Mathematics 1700, Precalculus Mathematics;
3. Mathematics 1840, Single Variable Calculus;
4. Mathematics 2110-20-30, Structure of the Number System;
5. Curriculum and Instruction 3752, Teaching of Mathematics:
Geometry and Analysis, Grades 7 - 12;
6. Curriculum and Instruction 5610, Educational Statistics;
and
7. English 1020, English Composition.

Four of the five sections of Mathematics 1540, three of the four sections of Mathematics 1700, and four of the nine sections of Mathematics 1840 participated in the study. The one section of Mathematics 2110, two of the three sections of Mathematics 2120, and the one section of Mathematics 2130 also participated in the study, as did Curriculum and Instruction 3752 (one section) and Curriculum and Instruction 5610 (one section). Finally, 7 of the 110 English 1020 sections participated in the study.

Students enrolled in these courses were from the colleges of Agriculture, Architecture, Business Administration, Communications, Education, Engineering, Home Economics, Liberal Arts, and Nursing. Their majors included the areas of agriculture, architecture, business, education, engineering, humanities, natural and physical science, and social and behavioral science.

Measurement of Math Anxiety

Math anxiety was measured by the scores on Plake and Parker's (1982) revised version of the Mathematics Anxiety Rating Scale (Richardson and Suinn, 1972), a 24-item scale developed to provide an efficient index of math anxiety. This scale will be discussed in more detail in Chapters II and III.

Measurement of Background and Experiential Factors

The responses on the Student Information Questionnaire (SIQ) developed by the investigator determined the two factors of college major and sex (for the two-way analysis of variance) and the six factors of mathematics background, mathematics achievement, mathematics performance, mathematics avoidance, self-rating of mathematics ability, and self-rating of mathematics anxiety (for the correlation study).

Procedures

During the second week of class the students received written explanations of the study, and each participant signed a consent form. (Copies of the consent forms are included in Appendix A.) The RMARS and the SIQ were administered to each student during the second week of class; seven weeks later, the RMARS was administered again.

V. ASSUMPTIONS OF THE STUDY

The following assumptions are implicit in this study:

1. Because the SIQ and the RMARS required students to answer questions about themselves, the usefulness of these instruments depended on the students' ability to remember information and feelings accurately and on their willingness to report these items candidly.

2. The investigator treated the RMARS scores as interval data as did previous authors (Brush, 1978; Rounds & Hendel, 1980a; and Resnick, Viehe, and Segal, 1982).

3. It was assumed that the classes were formed randomly through computer assignment.

VI. LIMITATIONS OF THE STUDY

1. The study was limited to students enrolled in those courses listed in Section IV. Therefore, the conclusions are applicable only to those populations or similar populations.

2. Of the 600 students who initially consented to participate in the study, data on only 173 were actually analyzed because of selecting criteria discussed in Chapter III.

VII. EXPLANATION OF NOTATION

The following symbols will be used in this study:

T8: the Technical Majors Group enrolled in Mathematics 1840

T7: the Technical Majors Group enrolled in Mathematics 1700

N: the Nontechnical Majors Group

M: the Mathematics Education Majors Group

E: the Elementary Education Majors Group

G: the Graduate Students Group

C: the Control Group

Ma: male

Fe: female

Pr: pretest, administered during the second week of school

Po: posttest, administered seven weeks later

SIQ: Student Information Questionnaire

Rs: Plake and Parker's revised version of the Mathematics Anxiety
Rating Scale (also RMARS)

These symbols are used together to indicate various combinations.

PrRsT8, for example, represents the pretest scores of the RMARS (administered during the second week of school) to the Technical Majors Group enrolled in Mathematics 1840.

VIII. STATISTICAL TREATMENT OF THE DATA

Levels of math anxiety (as measured by the RMARS) by sex and major were compared by a two-way analysis of variance design; $p < .05$ was considered significant. Post hoc comparisons of significant effects were made through Scheffe's method.

Changes in levels of math anxiety (as measured by the RMARS) from the beginning of the quarter to seven weeks later were ascertained through a t -test for correlated samples; $p < .05$ was again considered significant. Student's t -values were calculated both within each major and separately for males and females within each major.

Pearson product-moment correlation coefficients were calculated to describe the degree of relationship between math anxiety (as measured by the RMARS) and (1) mathematics background, (2) mathematics achievement, (3) mathematics performance, (4) mathematics avoidance, (5) self-rating of mathematics ability, and (6) self-rating of mathematics anxiety. Correlations were calculated both within each major and separately for males and females within each major.

Analysis of the RMARS

The RMARS was given to seven groups: the Nontechnical Majors Group, the Technical Majors Group enrolled in Mathematics 1700, the Technical

Majors Group enrolled in Mathematics 1840, the Elementary Education Majors Group, the Mathematics Education Majors Group, the Graduate Students Group, and the Control Group. Thus, a 2 x 7 factorial design resulted: 2 (male vs. female) x 7 (Nontechnical Majors vs. Technical Majors enrolled in Mathematics 1700 vs. Technical Majors enrolled in Mathematics 1840 vs. Elementary Education Majors vs. Mathematics Education Majors vs. Graduate Students vs. Control). The analysis of variance was computed with the RMARS as the dependent variable. The following null hypotheses were tested:

Ho1: There are no significant differences between male and female means on the RMARS across majors.

Ho2: There are no significant differences among the RMARS means for the Nontechnical Majors, Technical Majors enrolled in Mathematics 1700, the Technical Majors enrolled in Mathematics 1840, the Elementary Education Majors, the Mathematics Education Majors, the Graduate Students, and the Control groups.

Ho3: The interactions are each zero.

Changes in Levels of Math Anxiety

The RMARS was given during the second week of class (pretest) and seven weeks later (posttest) to the seven groups. The following null hypotheses were tested:

Ho4: There are no significant differences between pretest and posttest means on the RMARS within each major.

Ho5: There are no significant differences between RMARS pretest and posttest means for males and females within each major.

Degree of Relationship Between the RMARS Scores and the Six Background and Experiential Factors

Comparisons were made between pretest RMARS scores and the six background and experiential factors (described in the preceding sections) by calculating the Pearson product-moment correlation coefficients for each of the seven groups and separately for males and females within each group. The following null hypothesis was tested:

Ho6: The correlation coefficients are equal to zero.

IX. IMPORTANCE OF THE STUDY

The further study of math anxiety is worthwhile for several reasons. Most colleges and universities have developed criteria to help students determine which level of mathematics course is appropriate for them. These criteria include ACT (mathematics) cutoff points, recommended high school background courses, and mathematics placement tests. Although Tobias (1978), among others, has postulated that math anxiety may explain poor mathematics performance, information about a student's math anxiety is seldom used to provide placement guidance in mathematics courses. Using established levels of math anxiety to guide students in selecting their mathematics coursework might help place students in appropriate mathematics courses. Mathematics instructors could also use knowledge of a group's math anxiety to plan more effective class lectures.

Further study of the problem would also yield further insight into the multidimensionality of math anxiety. The RMARS, which mainly measures the dimensions of mathematics evaluation and problem-solving anxiety, may prove adequate in determining the math anxiety of students majoring in nonmathematics-related fields. However, many students taking calculus (which is required in mathematics-related fields) claim that they

experience math anxiety even though they score relatively low on instruments that measure math anxiety. Math anxiety may thus encompass more dimensions than those included in the current measuring instruments.

Finally, further study of the prevalence of math anxiety at The University of Tennessee, Knoxville, a large, Southern, state university, would help complete the overall picture of the prevalence of math anxiety in the United States.

X. ORGANIZATION OF THE STUDY

Chapter I includes a statement of the purpose, a list of the research questions, definitions of terms pertaining to the study, a brief description of the method, limitations and assumptions of the study, an explanation of the notation, a brief discussion of the statistical treatment of the data, and a discussion of the study's importance.

Chapter II is a literature review of the descriptions and measurements of math anxiety. Also included are research studies pertaining to the problem.

Chapter III describes the procedures, the subjects, and the measuring instruments used in the current study.

Chapter IV reports the results of the statistical analysis of the data.

Chapter V summarizes the study and states the conclusions.

CHAPTER II

LITERATURE REVIEW

For at least thirty years, psychologists and mathematics educators have been interested in anxiety over mathematics. This anxiety takes several names, including mathemaphobia, number anxiety, mathematics anxiety, mathophobia, and math anxiety. Few studies in the 1950's and 1960's explored the extent to which math anxiety correlates with success in mathematics. The feminist movement in the 1970's and articles in such popular magazines as Saturday Review, MS, Time, and Newsweek, finally brought math anxiety to the public's attention. From 1975 to the present, interest in the problem has intensified, and a serious movement to understand math anxiety has begun.

In 1975 Lazarus (Saturday Review), for example, claimed that "most people dislike--or fear--mathematics" (p. 46). He blamed the curricula in use at most schools for this aversion. In 1976 MS magazine carried an article by Sheila Tobias entitled "Why is a smart girl like you counting on your fingers?" Tobias referred to math anxiety as a "condition that disproportionately affects females" (p. 56). (Tobias has also written a book on the subject, Overcoming Math Anxiety, 1978.) In 1977 Time reported that females in particular are excluded from technical majors in college because of their avoidance of mathematics. Williams and King (Newsweek, 1980) reported on the dispute about sex differences in mathematics ability. Some claimed that the differences are environmental (Tobias, Ivans), while others claimed that they are genetic (Benbow and

Stanley). However, two years later, Time (1982) reported that sex differences in mathematics ability do not exist (Usiskin and Senk), that previous studies had actually measured mathematics performance, not innate ability.

This survey cites published material on the descriptions of math anxiety, on the measurements of math anxiety, and on the research studies pertaining to math anxiety in a college population.

I. DESCRIPTIONS OF MATH ANXIETY

Although in 1954 Sister Mary Fides Gough stated that "mathephobia needs no defining" since "the term is self-definitive" (p. 290), psychologists and mathematics educators have since attempted to define mathematics anxiety and its counterparts.

Of particular interest are the following four definitions which are each associated with their own instrument for measuring math anxiety. First, Dreger and Aiken (1957) investigated the presence of "a syndrome of emotional reactions to arithmetic and mathematics, tentatively designated 'number anxiety'" (p. 344), in college students.

Probably the most well-known description of math anxiety comes from Richardson and Suinn (1972), who stated that math anxiety involves "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551).

Also, Fennema and Sherman (1976) described math anxiety as "feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (p. 326). And Sandman (1980) defined math anxiety as "the uneasiness a student feels in situations involving mathematics" (p. 149).

Other researchers report similar definitions of math anxiety. In 1974, Lazarus referred to "mathophobia" as "an irrational and impeditive dread of mathematics A student can develop this emotional and intellectual block, making further progress in mathematics and closely related fields very difficult" (p. 16). Tobias (1976) described it as an "I can't" syndrome (p. 57). Donady and Tobias (1977) found math anxiety a "nonrational distaste for and avoidance of math and math-related subjects" (p. 71). Kogelman and Warren (1978) found it an "intense emotional reaction to math based on past experiences" (p. 9). Auslander (1979) defined math anxiety as the "experience of mental disorganization, panic, and fear that prevents a person from learning mathematics" (p. 17). Finally, Wagner (1980) stated that math anxiety is "tension, throbbing temples, thoughts like 'I don't know what it means,' 'I don't know how,' 'I don't understand,' 'I can't,' 'I hate it'" (p. 58).

II. MEASUREMENTS OF MATH ANXIETY

Measurements of math anxiety are needed for diagnosis and evaluation purposes. Of the instruments designed to measure math anxiety, four paper-and-pencil, self-report instruments will be reviewed: (1) the "Number Anxiety" items of the Taylor Scale of Manifest Anxiety, (2) the Mathematics Anxiety Scale of the Fennema-Sherman Mathematics Attitudes Scales, (3) the Anxiety Toward Mathematics Scale of the Mathematics Attitudes Inventory, and (4) the Mathematics Anxiety Rating Scale.

The "Number Anxiety" Items of the Taylor Scale of Manifest Anxiety

Dreger and Aiken (1957) included three more items on the Taylor Manifest Anxiety Scale that were "specifically designed to measure feelings of anxiety concerning working with numbers" (p. 345). The three

items were: (1) "I am often nervous when I have to do arithmetic," (2) "Many times when I see a math problem I just 'freeze up,'" and (3) "I was never as good in math as in other subjects." Reliability and validity data about this instrument are lacking.

The Mathematics Anxiety Scale of the Fennema-Sherman Mathematics Attitudes Scales

The Mathematics Anxiety Scale (MAS; Fennema and Sherman, 1976) is one of nine scales developed by Fennema and Sherman to measure attitudes related to mathematics learning. MAS is a 12-item, self-rating scale in a five-point Likert format. Items are general, e.g., "Mathematics makes me feel uneasy and confused" (item 7). Students are asked to indicate the degree to which they agree with each statement, from "strongly agree" to "strongly disagree." Administration time of the scale is approximately 5 minutes. A math anxiety score is calculated additively by scoring six of the items negatively and the other six positively, a high MAS score indicating a low level of math anxiety. MAS was developed for use with high school students, grades 9-12.

Fennema and Sherman reported scant reliability and validity data, but more information has recently become available. Betz (1978) reported a split-half reliability coefficient of .92. Rounds and Hendel (1980a) found that MAS correlated highly ($r = -.65$) with the Mathematics Test Anxiety Scale of the MARS, concluding that MAS seemed mainly to measure mathematics test anxiety. Dew (1982) (reported again in Dew, Galassi, and Galassi; 1983) found the MAS to have an internal consistency reliability coefficient of .72 and a 2-week test-retest reliability of .87. She also supported the construct validity of MAS. Finally, Ling (1982, 1983) (reported again in Frary and Ling, 1983) factor analysed five of the nine Fennema and Sherman math attitude scales (including MAS) and a

test anxiety scale. Math anxiety, test anxiety, and three of the attitude scales all loaded on one factor.

The Anxiety Toward Mathematics Scale of the Mathematics Attitudes Inventory

The Anxiety Toward Mathematics Scale (ATMS; Sandman, 1973, 1974) is one of six scales of the Mathematics Attitude Inventory (MAI). A six-item self-rating scale in a four-point Likert format, it measures the "uneasiness a student feels in situations involving mathematics" (Sandman, 1980, p. 149). Items are general, e.g., "working with numbers upsets me," and students indicate whether they strongly agree, agree, disagree, or strongly disagree with each item. Administration time of the scale is approximately four minutes. A math anxiety score is calculated by scoring additively, a high ATMS score indicating a high level of math anxiety. ATMS was designed to measure the attitudes of seventh-through twelfth-graders toward mathematics.

Sandman (1980) claimed support for the construct validity of the MAI. His factor analysis of the scores obtained from 5,034 representatively selected secondary mathematics students yields a factor structure that is "easily" interpretable with reference to each of the six scales. He calculated a Cronback alpha reliability coefficient of .76.

Dew (1982, and reaffirmed in Dew, Galassi and Galassi 1983) reported a two-week test-retest reliability of .75. However, Dew found an internal consistency reliability coefficient of .21. The construct validity of the ATMS was not supported by Dew.

The Mathematics Anxiety Rating Scale

The Mathematics Anxiety Rating Scale (MARS; Richardson and Suinn, 1972) is a single instrument developed by Richardson and Suinn 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). MARS is a 98-item self-rating scale in a five-point Likert format (some researchers used a 94-item version because a printing error omitted the last 4 items). Items are specific, e.g., "Being given a homework assignment of many difficult problems which is due the next class meeting" (Richardson and Suinn, 1972, item 72). Students are asked to respond to each item according to how much they are "frightened by it nowadays." Administering the scale takes approximately 45 minutes, and the student's math anxiety score is calculated by summing the response weights. (Weights range from 1 to 5 corresponding to the level of anxiety checked, from 1 meaning "not at all" to 5 meaning "very much"). A high MARS score indicates a high level of math anxiety. MARS was developed for use with college students.

Reliability. Many researchers have collected normative data on the MARS. Using a sample of 397 underclassmen (80% female) enrolled in education classes at a large state university in Missouri, Richardson and Suinn (1972) reported an internal consistency reliability coefficient of .97. A seven-week test-retest reliability coefficient obtained from two of the classes ($n = 35$) was .85.

Suinn, Edie, Nicoletti, and Spinelli (1972) collected data on a sample of 119 students at a large Colorado state university who volunteered to participate in the study. A two-week test-retest reliability coefficient was .78.

From their study of 59 elementary education majors enrolled in mathematics methods courses at the University of Akron, Sovchik, Meconi,

and Steiner (1981) reported MARS (98-item version) reliability coefficients of .978 and .982.

More recently, Dew (1982) collected data on a sample of 796 students enrolled in introductory classes at the University of North Carolina at Greensboro. She reported (reported again in Dew, Galassi, and Galassi; 1983) a reliability coefficient of .96 for the MARS and obtained a two-week test-retest reliability coefficient of .87.

Validity. Several types of information allowed researchers to determine construct validity. Two groups of researchers found negative correlations between MARS scores and the numerical ability test in the Differential Aptitude Tests. Richardson and Suinn (1972) collected data on a sample of 30 upperclassmen (about equally divided between males and females) enrolled in an advanced psychology class at a large state university in Missouri. The Pearson product-moment correlation coefficient between subjects' scores was $-.64$.

Suinn, Edie, Nicoletti, and Spinelli (1972) gathered data on a sample of 44 of the 119 students in their original Colorado sample, calculating correlations of $-.35$ for the original testing and $-.32$ for the retesting (conducted 2 weeks later).

Further support for the construct validity of the MARS was obtained from three studies which showed decreases in MARS scores after treatment interventions. Richardson and Suinn (1972) collected data from 10 Missouri students; Suinn, Edie, and Spinelli (1970) collected data from 13 Colorado students; and Suinn and Richardson (1971) collected data from 24 Colorado students. For all three studies, the decrease in MARS scores was statistically significant.

Support for the validity of the MARS was further provided by Brush (1978), who collected data on a sample of 109 upperclassmen majoring in Humanities, Social Science, or Physical Science at a private coeducational university. She reported negative correlations between MARS scores and the number of years of mathematics taken in high school ($\underline{r} = -.44$), MARS scores and enrollment in calculus in college ($\underline{r} = -.21$), and MARS scores and grades in previous mathematics courses ($\underline{r} = -.29$).

Studying a sample of 106 mathematics and psychology students, Morris, Kellaway, and Smith (1977) reported negative correlations between MARS scores for mathematics students and first exam grade ($\underline{r} = -.21$), final exam grade ($\underline{r} = -.21$) and course grade ($\underline{r} = -.22$); and between MARS scores for psychology students and first exam grade ($\underline{r} = -.37$) and course grade ($\underline{r} = -.30$).

More recently, Dew (1982) and Dew, Galassi, and Galassi (1983) have provided data in support of the validity of MARS. Dew gathered data on a sample of 63 students randomly selected by gender from a larger sample of 769 students in introductory classes at the University of North Carolina at Greensboro. She found that MARS scores have significant inverse relationships to mathematics performance (as measured by computational problems, $\underline{r} = -.39$, and word problems, $\underline{r} = -.41$).

Dimensionality. Researchers disagreed whether MARS is unidimensional or multidimensional. Richardson and Suinn (1972) stated that MARS items are "heavily dominated by a single homogeneous factor, presumably mathematics anxiety" (p. 553). Richardson and Woolfolk (1980) also found just one factor involving evaluative academic and problem-solving situations, accounting for 76% of the variance. They performed a principal components factor analysis with a varimax rotation of the factors on MARS

scores (98-item version) from the Richardson and Suinn (1972) study (397 underclassmen, 80% female, enrolled in education classes at a large state university in Missouri). Almost all MARS items correlated above .40 with total scores.

Other researchers found the MARS to be two- or three-dimensional. Brush (1978) also performed a principal components factor analysis with a varimax rotation of the factors on MARS scores (94-item version), the details of which were not contained in the report. Having gathered data on a sample of 189 upperclassmen majoring in Humanities, Social Science, or Physical Science at a private coeducational university, she reported that the factor analysis indicated the presence of two factors: Problem-Solving Anxiety (45 items) and Evaluation Anxiety (31 items). Examples of items loading on the former are "adding up $976 + 777$ on paper" (item 14) and "figuring the sales tax on a purchase that costs more than \$1.00" (item 48). Examples of items that loaded on the latter are "thinking about an upcoming math test one day before" (item 74) and "being given a homework assignment of many difficult problems which is due the next class meeting" (item 72).

Morris, Kellaway and Smith (1978) conducted a study of 106 mathematics and psychology students and identified three subscales of the MARS (94-item version): (1) Math Class Anxiety (8 items), (2) Math Studying Anxiety (9 items), and (3) Math Test Anxiety (10 items). The first subscale includes the MARS item "walking into a math class" (item 28); the second includes the MARS item "studying for a math test" (item 34); and the third includes the MARS item "taking an examination (quiz) in a math course" (item 53). No information was provided about how the

subscales were identified or how the items on each subscale were chosen. A complete list of the items on each subscale was unavailable.

Rounds and Hendel (1980a) collected data from 350 female participants in a mathematics-anxiety treatment program at a large midwestern university. They performed a principal components factor analysis with a direct oblimin and a varimax rotation of the factors on MARS scores (94-item version). Factor-pattern loadings were all greater than or equal to .30. Factor 1, with an eigenvalue of 29.12, was labeled Mathematics Test Anxiety and included 42 items such as "taking an examination (quiz) in a math course" (item 53) and "buying a math textbook" (item 23). Factor 2, with an eigenvalue of 7.68, was labeled Numerical Anxiety and included 44 items such as "having someone watch you as you total up a column of figures" (item 2), "totaling up a dinner bill that you think overcharged you" (item 10), and "determining the grade point average for your last term" (item 18).

Resnick, Viehe, and Segal (1982) studied freshmen ($n = 1106$) at a private, nonsectarian, coeducational institution. They factor analyzed the MARS (98-item version) scores using a principal component analysis and a varimax rotation. They identified three factors: (1) Evaluation Anxiety (19 items), (2) Social Responsibility Anxiety (4 items), and (3) Arithmetic Computation Anxiety (7 items). Evaluation anxiety had an eigenvalue of 30.15, compared with 5.08 and 4.35 for the other two factors. MARS item 75, "thinking about an upcoming math test 1 hour before," loaded on the Evaluation Anxiety factor; MARS item 12, "being treasurer for a club," loaded on the Social Responsibility Anxiety factor; and MARS item 69, "being given a set of multiplication problems to solve," loaded on the Arithmetic Computation Anxiety factor.

Thus, Brush (1978); Morris, Kellaway, and Smith (1978); Rounds and Hendel (1980a); and Resnick, Viehe, and Segal (1982) each identified at least two factors within the MARS, while Richardson and Suinn (1972) and Richardson and Woolfolk (1980) concluded that MARS was unidimensional. This discrepancy seems to be largely a matter of interpretation of the factor analysis, not a matter of the actual results of the procedure. In fact, Resnick, Viehe, and Segal (1982) concluded:

It is . . . very important to note that although the MARS does have a multidimensional structure, there is a single primary dimension, Factor 1 [Evaluation Anxiety], accounting for the largest part of the variance, with the two other factors accounting for significantly less.

.
In fact, Richardson and Suinn were correct in stating that the MARS as a test is highly reliable and "indicates that the test items are heavily dominated by a single homogeneous factor."
(p. 45)

Relationships Between the Math Anxiety Measures

Dew (1982) found that MARS and MAS correlate strongly with each other ($r = -.68$), indicating that they share common variance (46.24%) "that can be assumed to represent the construct of mathematics anxiety" (p. 117). Rounds and Hendel (1980b) found a correlation of $-.55$ between MARS and MAS. In particular, MAS correlated $-.65$ with the Mathematics Test Anxiety Scale and $-.27$ with the Numerical Anxiety Scale.

Revised Versions of MARS

Three groups of researchers have developed revised versions of the MARS. Richardson and Woolfolk (1980) chose the 40 MARS items that most highly correlated (from $.74$ to $.56$) with total MARS scores. These items described evaluative academic and problem-solving situations. Richardson and Woolfolk (1980) stated that

this 40-item scale is presumably at least as reliable, stable, and valid as the original AMRS [sic] and is almost certainly

dominated by a single homogeneous factor of anxiety concerning evaluative test-taking and problem-solving mathematics situations. We recommend its use in clinical and mathematics anxiety research. (p. 274)

Rounds and Hendel (1980a) developed scales representing the two MARS factors they identified from their factor analysis. They used a "sequential strategy of item selection . . . with the total sample to create the 15- to 20-item MARS factor derived scales" (p. 141). These scales were subsequently tested for certain expected discriminant or convergent relationships between the factor-derived measures of math anxiety and other specific anxiety scales and the measure of mathematics performance. Rounds and Hendel report that the internal consistency reliability coefficient alpha was .93 for the Mathematics Test Anxiety Scale and .87 for the Numerical Anxiety Scale. These coefficients "compared favorably" (p. 144) with the one reported by Richardson and Suinn (1972) for the total MARS (.97). Rounds and Hendel also reported a Pearson product-moment correlation coefficient of .34 between the two scales. They claimed that this coefficient supports that the two scales are independent math anxiety scales.

Plake and Parker (1982) developed a 24-item version of the MARS by choosing the items they believed measure "class-related anxiety in statistics courses" (p. 552). A principal components factor analysis with a normalized varimax rotation of this shortened version of MARS revealed two factors: (1) Learning Mathematics Anxiety and (2) Mathematics Evaluation Anxiety. An example of an item that loaded on the former is "watching a teacher work an algebraic equation on the blackboard" (item 25), and an example of an item that loaded on the latter is "being given a homework assignment of many difficult problems which is due the next class meeting" (p. 72). Plake and Parker investigated the 24-item MARS'

internal consistency and relationship to scores on the total MARS scale. They reported an internal consistency reliability of .98 and a correlation coefficient of .97 between their 24-item version and the original MARS.

III. STUDIES DESCRIBING MATH ANXIETY IN A COLLEGE POPULATION

Research focusing on math anxiety in a college population has dealt with the prevalence and intensity of math anxiety and the relationships between math anxiety and mathematics course and exam grades, sex of the student, age of the student, number of years of high school mathematics taken, college major, number of years elapsed since last mathematics course completed, and score on the ACT mathematics subtest. The results of these studies are seemingly inconsistent and inconclusive; the various researchers did not use the same instruments to measure math anxiety, nor did they use the same types of students, e.g., all females, only freshmen, only participants in a math anxiety reduction project.

Dreger and Aiken (1957) administered a three-item Number Anxiety Scale to measure the math anxiety of 704 basic mathematics students at a large Florida university. They reported that 35% of the students in that sample had "high" levels of math anxiety. They concluded that "number anxiety" and general anxiety appeared to be separate constructs, that "number anxiety" and general intelligence did not seem to be related, but that high "number anxiety" was significantly related to lower mathematics grades ($\underline{r} = -.44$, $n = 704$; $\underline{r} = -.51$, $n = 40$).

Aiken (1970) reported only one study dealing with math anxiety conducted during the 1960's. In this study, Natkin (1966, 1967) devised

a treatment to reduce math anxiety which involved using Galvanic Skin Reactions to measure math anxiety.

Richardson and Suinn (1972) administered the MARS to 397 freshmen and sophomores (80% female) in beginning education classes at a large Missouri state university. They found that math anxiety was a "fairly common" problem in their sample. However, no significant differences existed between mean MARS scores for males and females. The Pearson product-moment correlation coefficient between MARS scores and Differential Aptitude Test scores (a commonly used test made up of mathematical problems that range from simple to increasingly complex) was $-.64$ ($p < .01$), "indicating that high MARS scores are associated with poor performance on the mathematics test" (p. 553).

Based on the results of administering a revised version of the Mathematics Anxiety Scale (MAS; Fennema and Sherman, 1976) to 652 underclassmen enrolled in basic mathematics, precalculus or psychology, Betz 1978 concluded that math anxiety occurred "frequently" among college students, especially among women and students with "inadequate" high school backgrounds. She conjectured that math anxiety "may be problematic even for those students who plan majors and/or careers requiring extensive math background" (p. 446). Betz also found that lower reported levels of math anxiety were related to higher achievement in mathematics as measured by test scores on the ACT Mathematics subtest, and lower test anxiety as measured by Spielberger's Test Anxiety Inventory.

Brush (1978) conducted a study involving two samples of upperclassmen at a private coeducational university. Both samples contained Humanities, Social Science, and Physical Science majors, approximately evenly divided between males and females. She reported that there were significant differences ($F = 7.12$ and $F = 5.63$, $p < .01$) between MARS

(94-item version) scores of Humanities, Social Science, and Physical Science majors, from highest to lowest, respectively. With regard to sex differences on MARS scores, Brush observed that in one of her samples, females scored significantly higher than males, but in her other sample, no sex differences were found. She concluded that students who took 2 - 3 years of mathematics in high school scored significantly higher ($r = -.44$) on MARS than students who took 4 - 5 years of mathematics in high school. Also, students with higher MARS scores were less frequently enrolled in calculus ($r = -.21$) and received lower grades in mathematics ($r = -.29$). Higher MARS scores were positively correlated with dislike of mathematics ($r = .39$) and feelings of anxiety about mathematics ($r = .34$).

Morris, Kellaway, and Smith (1978) conducted a study involving 106 college mathematics and psychology students. They found that MARS (94-item version) scores were higher for psychology students than for mathematics students ($t = 2.24$, $p < .05$) and were inversely related to performance as measured by final exam ($r = -.37$) and course grade ($r = -.30$) for psychology students. They found no sex differences in MARS scores.

Boodt (1979, 1980) administered the 98-item version of MARS to 228 remedial algebra students at a large metropolitan midwest university. She found a significant reduction in the level of math anxiety (over the period of one semester) when students were grouped according to sex.

Lavroff (1980) randomly sampled 237 upper level students from 80 public colleges and universities in 50 states. He concluded that math anxiety (as measured by MARS) correlated more highly with choice of academic major than sex, that math anxiety appeared to operate as an

"inhibitor" in the choice of majors for students who reported MARS scores above the sample average, and that females were affected by math anxiety in the selection of majors more than males (with female education majors reporting the highest math anxiety scores).

Calvert (1981) conducted a correlational study involving 441 precalculus mathematics students. She concluded that mean MARS scores differed by sex, females scoring significantly higher than males. She also found an inverse relationship between MARS scores and the level of mathematics course previously completed, with students completing only a general mathematics course having the highest MARS scores. She did not find a significant difference among the levels of math anxiety experienced by persons of different ages. However, she did find that students receiving low grades (C, D, or F) in their previous mathematics course had higher levels of math anxiety than students who had received high grades (A or B).

Sovchik, Meconi, and Steiner (1981) reported a statistically significant ($t = 4.29$, $p < .05$) math anxiety reduction (as measured by MARS) from pretest to posttest in 59 students enrolled in a preservice elementary mathematics methods course. They tentatively concluded that taking the mathematics methods course reduced the math anxiety of these students.

Dew (1982) conducted a study involving 769 students enrolled in introductory classes at a southeastern university. Dew (reaffirmed in Dew, Galassi, and Galassi, 1983) found sex-related differences on MARS scores, with females scoring higher. But she judged the differences to be relatively small, a mean of 185.456 for males compared to 193.891 for females. Dew computed a correlation of .55 between the MARS and the TAI (Test Anxiety Inventory, Spielberger, 1977). She concluded that math

anxiety was related to test anxiety, but not equivalent to it. Dew, Galassi, and Galassi (1984) further stated that math anxiety, as measured by MARS (98 items), was significantly and inversely related for two tasks (numerical computations and word problems in a test-like situation). They concluded that "math anxiety had only a modest relation to math performance" (p. 583).

Resnick, Viehe, and Segal (1982) found that 1106 college freshmen at a private, nonsectarian coeducational institution had low levels of math anxiety, as measured by MARS (98-item version). They also reported that there were no large sex differences in degree of math anxiety. Math anxiety was found more prevalent among students enrolled in precalculus than among students enrolled in the standard calculus sequence. Correlations between MARS scores and grades ranged from .005 to .276, all non-significant.

Themes (1982) conducted a study involving 61 women, age range 18 - 60, at a small, private Ohio college. She found no significant correlation between MARS scores and grade point average in mathematics, age, number of mathematics courses completed, and length of time since last mathematics course.

Sherman (1983) compared the mathematics attitudes of 63 girls who took two or three years of high school mathematics. Results confirmed that fear of mathematics decreased in girls continuing in mathematics, and attitudes towards mathematics became more positive.

Ling (1982, 1983) and reaffirmed in Frary and Ling (1983) reported no sex differences in mean scores for the MAS. Their conclusion was based on a study involving 491 university students enrolled in mathematics courses (largely nontechnical majors) at a large, moderately selective state university. They did report that higher levels of math

anxiety were associated with lower levels of mathematics completed in high school, lower college grade point averages, and lower course grades.

Finally, Fee-Fulkerson (1982) and reported again in Fulkerson, Galassi, and Galassi (1984) found that math anxiety, as measured by MARS, (98 items) was not significantly related to mathematics performance, as measured by solving mathematical problems taken from the Scholastic Aptitude Test. They also concluded that cognitions do not vary as a function of math anxiety or sex. Subjects for the study were 71 students, randomly selected by sex, from 582 students in large introductory-level classes conducted at the University of North Carolina at Chapel Hill.

In summary, the majority of studies found math anxiety to be significantly inversely related to performance in mathematics as measured by achievement tests (Betz, 1978) and as measured by mathematics course and examination grades (Dreger and Aiken, 1957; Richardson and Suinn, 1972; Brush, 1978; Morris, Kellaway, and Smith, 1978; Calvert, 1981; Frary and Ling, 1983). One study even obtained both significant and nonsignificant relations between math anxiety and various math performance tasks (Dew, Galassi, and Galassi, 1984); and two studies found that math anxiety was not significantly related to math performance (Resnick, Viehe, and Segal, 1982; Fulkerson, Galassi, and Galassi, 1984).

Most of the data suggested that math anxiety is a common phenomenon among college students (Dreger and Aiken, 1957; Richardson and Suinn, 1972; Betz, 1978). However, Resnick, Viehe, and Segal (1982) ascertained that from the results of their study only a small number (2% of their sample of 1106) reported high levels of math anxiety. So the prevalence of math anxiety may vary considerably from one college population to another.

The studies agree that the more years of high school mathematics successfully completed, the lower the level of math anxiety (Brush, 1978; Calvert, 1981; Resnick, Viehe, and Segal, 1982; Themes, 1982; Frary and Ling, 1983). However, in the study that correlated the number of years since the last mathematics course was completed, Themes (1982) reported a lack of significance.

The literature seems to agree that the more technical the major, the lower the level of math anxiety reported (Morris, Kellaway, and Smith, 1978; Brush, 1978; Lavroff, 1980; Resnick, Viehe, and Segal, 1982).

However, the literature was divided as to whether there are sex-related differences in math anxiety. Betz (1978), Calvert (1981), and Dew, Galassi, and Galassi (1983) found math anxiety more prevalent in women. In one of her samples, Brush, (1978) found sex-related differences in math anxiety, with women being more math anxious, but she found no sex-related differences in another sample. Richardson and Suinn (1972), Resnick, Viehe, and Segal (1982), and Frary and Ling (1983) found no sex-related differences in math anxiety.

IV. SUMMARY

This chapter has discussed the historical background of math anxiety and presented various descriptions of math anxiety. It may be concluded that math anxiety does exist in college populations and that math anxiety can be measured by using Plake and Parker's revised version of the Mathematics Anxiety Rating Scale.

Several studies were reported which suggested relationships between math anxiety and choice of major in college, sex, performance in mathematics, and experience in mathematics. However, the studies frequently

disagreed on the nature of the relationships. Because further exploration of the possible relationships between intensity of math anxiety and several key variables would prove valuable, the major hypotheses of the present study evolved.

CHAPTER III

METHOD

This chapter describes the students participating in the study, the measuring instruments used, the curriculum of courses involved in the study, and the procedures followed.

I. THE PARTICIPANTS IN THE STUDY

Participants in the study included students enrolled in:

1. College Algebra (Mathematics 1540),
2. Precalculus Mathematics (Mathematics 1700),
3. Single Variable Calculus (Mathematics 1840),
4. Structure of the Number System (Mathematics 2110-2120-2130),
5. Teaching of Mathematics: Geometry and Analysis, Grades 7 - 12 (Curriculum and Instruction 3752),
6. Educational Statistics (Curriculum and Instruction 5610),
and
7. English Composition (English 1020)

during Winter Quarter, 1985, at The University of Tennessee, Knoxville. The students were about evenly divided between males and females (44% males and 56% females). In particular, however, the Technical Majors Group was predominantly male, while the Elementary Education Majors Group and the Graduate Students Group were predominantly female. The other three groups, Nontechnical Majors, Mathematics Education Majors, and the

Control Group, were fairly evenly divided between males and females. About 40% of the students were Technical Majors, 12% were Nontechnical Majors, 25% were Education Majors, 9% were Graduate Students, and 14% were in the Control Group.

During the second week of school, administrators read a common introductory statement to each class briefly explaining the study and the students' role in it. Students agreeing to participate in the study signed written consent forms and indicated their age range (either under 18 or 18 and older). Students under 18 years old were not included in the study. (Copies of the consent forms are included in Appendix A.)

For consenting students to be included in the study, they had to meet these conditions:

- * be 18 or older (so that parental permission was not required).

- * have completed the RMARS on the initial and final testing dates (because only students who completed the course were included in the study).

- * have completely and properly answered all questions on the SIQ and the RMARS (because only students for which all data was available were included in the study).

- * have the ACT mathematics subtest score on their permanent record (except for Curriculum and Instruction 5610 students who, because they were graduate students, did not have ACT scores on file).

- * never have participated in a math anxiety treatment program (because participation in such a program might affect their level of math anxiety).

- * not be repeating their mathematics-related course (because repeating a course might affect their level of math anxiety).

* not represent the major typical of the mathematics-related course (for example, an English major enrolled in Mathematics 1840--a Technical Majors Group).

In addition, those in the Control Group were rejected if they were enrolled in a mathematics course.

Of the 600 students who initially consented to participate in the study, data on only 173 were actually analyzed. Almost one-half of those who were not included in the study were rejected because they were not present on the date the final testing was done. Over 20% could not be included in the study because they were in the Control Group (enrolled in English 1020) but were also taking a mathematics course. Approximately 15% did not fill out the instruments (SIQ and RMARS) properly. The remaining 15% were rejected because of age, grade, major, or other selecting criteria discussed previously.

In particular, of the 101 students in the Nontechnical Majors Group who were initially tested, only 20 students were actually included in the study. In the Technical Majors Group, 224 students completed the initial testing (76 from Mathematics 1700 and 148 from Mathematics 1840), while only 70 students were actually included (17 from Mathematics 1700 and 53 from Mathematics 1840). Thirty-one of the 92 Elementary Education Majors, 13 of the 22 Mathematics Education Majors and 15 of the 27 Graduate Students were actually included in the study. Only 24 of the 129 English 1020 students who initially completed the RMARS and the SIQ became the Control Group. Other relevant data are summarized in Table 1.

TABLE 1
BREAKDOWN OF REJECTED CONSENTING STUDENTS BY CATEGORY

GROUP	INITIAL	1	2	3	4	5	6	7	ANALYZED
NONTECHNICAL	101	2	51	18	2	0	8	0	20
TECHNICAL-1700	76	2	26	11	0	0	20	0	17
TECHNICAL-1840	148	3	53	10	7	2	14	6	53
ELEMENTARY	97	0	38	11	3	2	2	10	31
MATH ED	22	2	4	2	1	0	0	0	13
GRADUATE	27	0	6	5	—	1	0	0	15
CONTROL	129 *	0	12	7	0	0	—	—	24

*: For the Control Group, 86 students were enrolled in a mathematics course, and were not included in the study.

Key:

- 1: under 18 years of age
- 2: did not complete RMARS on final testing date
- 3: did not fill out RMARS/SIQ completely
- 4: did not have ACT mathematics subtest on permanent record
- 5: participated in a math anxiety treatment program
- 6: repeating mathematics-related course
- 7: untypical major

II. THE MEASURING INSTRUMENTS

Revised Mathematics Anxiety Rating Scale (RMARS)

A 24-item version of the Mathematics Anxiety Rating Scale (RMARS), developed by Plake and Parker, measured the math anxiety of each participant. Each item on the RMARS represents mathematical tasks and experiences which potentially arouse anxiety or apprehension. The student indicates whether he is "not at all," "a little," "a fair amount," "much," or "very much" "frightened by it [the task or experience] nowadays." Although these responses constitute ordinal data, the investigator followed the common practice of assuming they could be converted to interval data by taking on the numerical value 1 for "not at all," 2 for "a little," 3 for "a fair amount," 4 for "much," and 5 for "very much." RMARS scores are the sums of these values; scores could thus range from 24 to 120. (Appendix A includes a copy of the RMARS.)

Plake and Parker (1982) collected normative data on a sample of 170 students enrolled in introductory statistics classes at a large, urban, midwestern university. The mean score for the sample was 59.84, and the standard deviation was 20.55. The internal consistency (coefficient alpha) reliability was 0.98. To determine the validity of the RMARS, Plake and Parker administered both the RMARS and a 48-item Mathematics Achievement Test (MAT). The MAT, derived from items on the ACT mathematics subtest, has a reliability coefficient of 0.91 as estimated by the Kuder-Richardson formula 20. The correlation coefficient between the RMARS and the MAT was -0.45. Plake and Parker also reported that the correlation between the RMARS and the MARS was .97. They further found that the dimensionality of the RMARS was similar to that of the MARS, the original 98-item scale. The principal components factor

analysis that they performed indicated a two-factor solution: Learning Mathematics Anxiety (16 items) and Mathematics Evaluation Anxiety (8 items). These factors accounted for 60% of the total variance. Each item had a factor loading of .50 or greater on only one of the two factors.

Student Information Questionnaire (SIQ)

The investigator developed the SIQ to determine for each participant the (1) college major, (2) sex, (3) highest level of mathematics course successfully completed, (4) score on the ACT mathematics subtest, (5) grade received in current mathematics course, (6) lapse of time since last successfully completed a mathematics course, (7) self-rating of mathematics ability, and (8) self-rating of mathematics anxiety. (A copy of the SIQ is included in Appendix A.)

In order to determine the level of each mathematics course on the list from the SIQ, each mathematics course was assigned a code number representing its position in the overall sequential arrangement of mathematics courses. (A copy of the code for the mathematics courses is included in Appendix D).

III. THE CURRICULUM OF THE COURSES INVOLVED IN THE STUDY

Except for those in the control group, all students who participated in the study were enrolled in some sort of mathematics-related course. This section outlines the topics taught in each of the courses.

College Algebra (Mathematics 1540)

The topics covered in College Algebra are: sets, real and complex number systems, exponents and radicals, fundamental algebraic operations, theory of equations, polynomial inequalities, relations, functions, and

graphs. The prerequisites for College Algebra are either (1) two years of high school algebra, or (2) one year of algebra and one year of geometry.

Precalculus Mathematics (Mathematics 1700)

The topics covered in Precalculus Mathematics are: function concept and use of functional notation, properties of functions and their graphs, and polynomial, exponential, logarithmic, and trigonometric functions. The prerequisites for Precalculus Mathematics are (1) two years of high school algebra and (2) the equivalent of a half-year of trigonometry or a concurrent Mathematics 0150 (Trigonometry) course.

Single Variable Calculus (Mathematics 1840)

The topics covered in Single Variable Calculus are: 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. The prerequisites for Single Variable Calculus are two years of high school algebra, one year of geometry, and one-half year of trigonometry or the equivalent.

Structure of the Number System (Mathematics 2110-20-30)

The topics covered in Structure of the Number System are: set theory, whole numbers, and integers. The prerequisites for Structure of the Number System are (1) one year of high school algebra and (2) at least sophomore standing in elementary education or the instructor's consent.

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

The topics covered in this course are: purposes, techniques, materials, and evaluation; directed observation in public schools; and preparation of teaching plans and materials. This course is required for certification in mathematics. Its prerequisite is admission to Teacher Education.

Educational Statistics (Curriculum and Instruction 5610)

The purposes of this course are:

- (1) To introduce some fundamental concepts of descriptive and inferential statistics as applied to educational problems,
- (2) To introduce the use of the hand-held calculator as a means of computing statistical measures, and
- (3) To learn to apply the use of certain statistical measures to educational problems, particularly, in research.

English Composition (English 1020)

English Composition is required for most students at The University of Tennessee, Knoxville, regardless of major. Students taking this course were chosen for the Control Group because they represented different majors and because some of them were not concurrently enrolled in a mathematics course.

IV. PROCEDURES FOR THE GROUPS

The RMARS and the SIQ were administered to students in their normal classroom situation during the last part of class in the second week of school (Monday, January 14 - Friday, January 19, 1985). To facilitate

the students' responding openly and honestly, the instructors did not administer the instruments to their own classes. Administrators were selected from those mathematics graduate students and faculty who volunteered to assist the investigator. They were scheduled according to their availability at the times of the participating classes.

During the quarter the students met at their regular class times, following the normal curriculum for each course in all of these sessions.

On Monday, February 25, 1985 (or the closest available date on which no exam was given), the RMARS was again administered to the students. The same administrator conducted this retesting.

V. SUMMARY

The purpose of this chapter was to describe the participants in the study, to discuss the RMARS and the SIQ, and to outline the procedures used with each of the sections of the courses involved in the study.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents results of the analysis of the Revised Mathematics Anxiety Scale (RMARS) scores, the changes in math anxiety levels from pretest to posttest, and the degree of relationship between RMARS scores and the six background and experiential factors: (1) mathematics background, (2) mathematics achievement, (3) mathematics performance, (4) mathematics avoidance, (5) self-rating of mathematics ability, and (6) self-rating of mathematics anxiety. (RMARS scores have been included in Appendix B.)

I. ANALYSIS OF THE REVISED MATHEMATICS ANXIETY RATING SCALE

Experimental Design and Statement of the Hypotheses for the Two-Way Analysis of Variance

The Revised Mathematics Anxiety Rating Scale was administered to all seven groups: the Nontechnical Majors Group, the Technical Majors Group enrolled in Mathematics 1700, the Technical Majors Group enrolled in Mathematics 1840, the Elementary Education Majors Group, the Mathematics Education Majors Group, the Graduate Students Group, and the Control Group. The data were analyzed by an analysis of variance with the RMARS score as the dependent variable and with two independent variables: (1) sex of the student, and (2) the group the student belonged to. Because there were no males in the Elementary Education Majors Group and only one in the Graduate Students Group, these groups were omitted from the two-

way analysis. Thus, a 2 x 5 factorial design resulted: 2 (male vs. female) x 5 (Nontechnical Majors vs. Technical Majors enrolled in Mathematics 1700 vs. Technical Majors enrolled in Mathematics 1840 vs. Mathematics Education Majors vs. Control). This design defined ten combinations:

1. male Nontechnical Majors, MaRsN;
2. female Nontechnical Majors, FeRsN;
3. male Technical Majors enrolled in Mathematics 1700, MaRsT7;
4. female Technical Majors enrolled in Mathematics 1700, FeRsT7;
5. male Technical Majors enrolled in Mathematics 1840, MaRsT8;
6. female Technical Majors enrolled in Mathematics 1840, FeRsT8;
7. male Mathematics Education Majors, MaRsM;
8. female Mathematics Education Majors, FeRsM;
9. male Control, MaRsC; and
10. female Control, FeRsC.

The two-way analysis of variance tested the following hypotheses:

Ho1: There are no significant differences between male and female means on the Revised Mathematics Anxiety Rating Scale across majors.

Ho2: There are no significant differences among the RMARS means for the Nontechnical Majors, the Technical Majors enrolled in Mathematics 1700, the Technical Majors enrolled in Mathematics 1840, the Mathematics Education Majors, and the Control groups.

Ho3: The interactions are each zero.

Results of the Two-Way Analysis of Variance. Table 2 shows the mean and the standard deviation for each of the ten combinations, and Table 3 summarizes the analysis of variance. Results show a significant group

TABLE 2
MEANS AND STANDARD DEVIATIONS OF SCORES ON THE RMARS
FOR FIVE OF THE GROUPS (MALES AND FEMALES)

<u>GROUP</u>	<u>MALES</u>			<u>FEMALES</u>		
	N	M	SD	N	M	SD
Nontech	7	53.14	21.19	13	54.54	24.68
Tech 1700	12	44.92	11.2	5	47	15.89
Tech 1840	40	51.85	13.59	13	47.69	10.76
Math Ed	6	50.67	16.69	7	31.71	5.5
Control	10	55.9	16.5	14	73.93	22.32

Note: RMARS scores may range from 24 to 120; higher scores indicate higher levels of math anxiety.

TABLE 3

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

SOURCE OF VARIATION	SUM OF SQUARES	<u>df</u>	MEAN SQUARE	<u>F</u>
SEX (S)	2.36	1	2.36	.01
GROUP (G)	5980.55	4	1495.14	5.56 **
S X G	3256.4	4	814.1	3.02 *
ERROR	31489.46	117	269.14	

* Significant at .05 level.

** Significant at .01 level.

effect and a significant interaction effect, thus the null hypotheses for the group effect and the interaction effect were rejected. Results did not, however, show a significant sex effect; thus the null hypothesis was not rejected for this effect.

Results of Scheffe's Test. Since the group and interaction effects were the only significant effects for the analysis of variance, Scheffe's method was used to compare the group means for males and females in 45 pairwise contrasts. Figure 1 details the results: a significant difference existed between the mean of the female Control Group and the means of both the female Mathematics Education Group and the Technical Majors Group enrolled in Mathematics 1700.

Discussion of the Results.

1. It was found that there were no sex-related differences in math anxiety. This is in contrast with some studies (Betz, 1978; Calvert, 1981; Dew, Galassi, and Galassi, 1983), which found math anxiety more prevalent in women, but not with others (Richardson and Suinn, 1972; Resnick, Viehe, and Segal, 1982; and Frary and Ling, 1983). One study has even obtained both significant and nonsignificant sex differences (Brush, 1978).

2. Math anxiety as measured by the RMARS was significantly different in only two of the 45 pairwise contrasts. The math anxiety of the females in the Control Group was significantly higher than the math anxiety of both the female Mathematics Education Majors and the male Technical Majors enrolled in Mathematics 1700.

3. The interaction between group and sex was found in the Mathematics Education majors and the Technical majors enrolled in Mathematics 1700. For the females, Mathematics Education majors had the lowest RMARS

MFe	T7Ma	T7Fe	T8Fe	MMa	T8Ma	NMa	NFe	CMa	CFe
31.71	44.92	47	47.69	50.67	51.85	53.14	54.54	55.9	73.93

Note: Those means underlined by the same line are not significantly different ($p < .05$). MFe and T7Ma are significantly lower than CFe.

Key:

MFe: Mathematics Education Females
T7Ma: Technical Mathematics 1700 Males
T7Fe: Technical Mathematics 1700 Females
T8Fe: Technical Mathematics 1840 Females
MMa: Mathematics Education Males
T8Ma: Technical Mathematics 1840 Males
NMa: Nontechnical Males
NFe: Nontechnical Females
CMa: Control Males
CFe: Control Females

Figure 1. Scheffe's comparisons of males and females on RMARS means following a significant two-way analysis of variance.

scores of all the five groups, with the Technical majors enrolled in Mathematics 1700 having the second lowest scores. For the males, however, Technical Majors enrolled in Mathematics 1700 had the lowest RMARS scores, with the Mathematics Education majors having the second lowest. For both males and females, the Control Group had the highest RMARS scores, followed by the Nontechnical Majors Group and the Technical Majors enrolled in Mathematics 1840.

Experimental Design and Statement of the Hypotheses for the One-Way Analysis of Variance

Because the Elementary Education Majors and the Graduate Students lacked enough males to be included in the two-way Analysis of Variance, a one-way Analysis of Variance disregarding the sex variable was performed. The data were subsequently analyzed by an analysis of variance with group as the only independent variable and the RMARS score as the dependent variable. All seven groups were thus included:

1. Nontechnical Majors, RsN;
2. Technical Majors enrolled in Mathematics 1700, RsT7;
3. Technical Majors enrolled in Mathematics 1840, RsT8;
4. Elementary Education Majors, RsE;
5. Mathematics Education Majors, RsM;
6. Graduate Students, RsG; and
7. Control, RsC.

The analysis of variance tested the following hypothesis:

Ho2b: There are no significant differences among the RMARS means for the Nontechnical Majors, the Technical Majors enrolled in Mathematics 1700, the Technical Majors enrolled in Mathematics 1840, the Elementary Education Majors, the Mathematics Education Majors, the Graduate Students, and the Control Group.

Results of the One-Way Analysis of Variance. Table 4 shows the mean and standard deviation for each of the seven groups, and Table 5 summarizes the analysis of variance. Results show a significant group effect; thus the null hypothesis was rejected.

Results of Scheffe's Test. Scheffe's method was used to compare the means of the 7 groups via 21 pairwise contrasts; results are summarized in Figure 2. A significant difference existed between the means for the Control Group and the means of (1) the Technical Majors enrolled in Mathematics 1700, (2) the Technical Majors enrolled in Mathematics 1840, and (3) the Mathematics Education Majors.

Discussion of the Results. Math anxiety as measured by the RMARS was significantly different in three of the 21 pairwise contrasts. The math anxiety of the Control Group was significantly higher than the math anxiety of (1) the Technical Majors enrolled in Mathematics 1700, (2) the Technical Majors enrolled in Mathematics 1840, and (3) the Mathematics Education Majors.

Students enrolled in the less rigorous mathematics-related sequences--Curriculum and Instruction 5610, Mathematics 2110-20-30, and Mathematics 1540--had more math anxiety than students in the more rigorous mathematics-related sequences--Mathematics 1840, Mathematics 1700, and Curriculum and Instruction 3752. These students also had (1) poorer mathematics backgrounds, (2) lower scores on the ACT mathematics subtest and (3) longer lapses of time since their last mathematics course. The observation that students with the less technical majors display higher levels of math anxiety supports what has been suggested in the literature (Morris, Kellaway, and Smith, 1978; Brush, 1978; Lavroff, 1980; Resnick, Viehe, and Segal, 1982).

TABLE 4
MEANS AND STANDARD DEVIATIONS OF SCORES ON THE RMARS
FOR EACH OF THE SEVEN GROUPS

GROUP	N	MEAN	STANDARD DEVIATION
NONTECHNICAL	20	54.05	22.95
TECHNICAL 1700	17	45.53	12.26
TECHNICAL 1840	53	50.83	12.98
ELEM ED	31	58.06	15.32
MATH ED	13	40.46	15.1
GRAD	15	60.47	23.94
CONTROL	24	66.42	21.69

Note: RMARS scores may range from 24 to 120; higher scores indicate higher levels of math anxiety.

TABLE 5

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

Source of Variation	Sum of Squares	<u>df</u>	Mean Square	<u>F</u>
Group	8967.99	6	1494.67	4.98 **
Error	49803.33	166	300.02	

** Significant at .01 level.

M	T7	T8	N	E	G	C
40.46	45.53	50.83	54.05	58.06	60.47	66.42

Note: Those means underlined by the same line are not significantly different ($p < .05$). M, T7, and T8 are significantly lower than C.

Key:

M: Mathematics Education
T7: Technical Mathematics 1700
T8: Technical Mathematics 1840
N: Nontechnical
E: Elementary Education
G: Graduate
C: Control

Figure 2. Scheffe's comparison of groups on RMARS following a significant one-way analysis of variance.

II. CHANGES IN MATH ANXIETY LEVELS

The RMARS was both a pretest (during the second week of class) and a posttest (seven weeks later) of the Nontechnical Majors Group, the Technical Majors Group enrolled in Mathematics 1700, the Technical Majors Group enrolled in Mathematics 1840, the Elementary Education Majors Group, the Mathematics Education Majors Group, the Graduate Students Group, and the Control Group. A t-test for correlated groups was used to analyze the data, defining 14 combinations:

1. pretest Nontechnical Majors, PrRsN;
2. posttest Nontechnical Majors, PoRsN;
3. pretest Technical Majors enrolled in Mathematics 1700, PrRsT7;
4. posttest Technical Majors enrolled in Mathematics 1700, PoRsT7;
5. pretest Technical Majors enrolled in Mathematics 1840, PrRsT8;
6. posttest Technical Majors enrolled in Mathematics 1840, PoRsT8;
7. pretest Elementary Education Majors, PrRsE;
8. posttest Elementary Education Majors, PoRsE;
9. pretest Mathematics Education Majors, PrRsM;
10. posttest Mathematics Education Majors, PoRsM;
11. pretest Graduate Students, PrRsG;
12. posttest Graduate Students, PoRsG;
13. pretest Control, PrRsC; and
14. posttest Control, PoRsC.

The t-test for correlated groups tested the following hypotheses:

Ho4: There are no significant differences between pretest and posttest means on the Revised Mathematics Anxiety Rating Scale within each major.

Ho5: There are no significant differences between RMARS pre-test and posttest means for males and females within each major.

Results of the t-test

Table 6 lists the mean and standard deviation of the pre- and post-test for each of the seven groups, and summarizes each group's t-tests for correlated groups. Results show a significant difference between the pretest and posttest means for two of the seven groups: the Technical Majors enrolled in Mathematics 1700 and the Technical Majors enrolled in Mathematics 1840.

Table 7 lists the mean and standard deviation of the males for 10 of the 14 combinations (PrRsE, PoRsE, PrRsG, and PoRsG were omitted because of small size), and summarizes the t-test for the males. Results show a significant difference between the pretest and posttest means for two of the five groups: the Technical Majors enrolled in Mathematics 1700 and the Technical Majors enrolled in Mathematics 1840.

Table 8 lists the mean and standard deviation of the females for each of the 14 combinations, and summarizes the t-test for the females. The results show no significant difference between the pretest and posttest means for any of the seven groups.

Discussion of the Results

1. Math anxiety as measured by the RMARS significantly decreased within the Technical Majors Group enrolled in Mathematics 1700 and the Technical Majors Group enrolled in Mathematics 1840, and it significantly decreased for males within both of the Technical Majors Groups. However, the decrease was not significant for the females within the Technical Majors Groups.

TABLE 6

THE t TESTS FOR DIFFERENCES BETWEEN PRETEST AND POSTTEST MEANS
OF THE RMARS FOR EACH OF THE SEVEN GROUPS

GROUP	N	PRETEST	POSTTEST	DIFFERENCE	t
NONTECH	20	54.05	51.5	2.55	.94
TECH 1700	17	45.53	41	4.53	2.24 *
TECH 1840	53	50.83	48.42	2.41	2.04 *
ELEM ED	31	58.06	57.45	.61	.25
MATH ED	13	40.46	41.77	-1.31	-.66
GRAD	15	60.47	57.33	3.14	1.09
CONTROL	24	66.42	66.08	.34	.14

* Significant at .05 level.

TABLE 7

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

GROUP	N	PRETEST	POSTTEST	DIFFERENCE	t
NONTECH	7	53.14	49.57	3.57	.72
TECH 1700	12	44.92	39.92	5	2.11 *
TECH 1840	40	51.85	49.2	2.65	1.92 *
MATH ED	6	50.67	52.67	-2	-.47
CONTROL	10	55.9	55.3	.6	.14

* Significant at .05 level.

TABLE 8

THE $\underline{t}$ TESTS FOR DIFFERENCES BETWEEN PRETEST AND POSTTEST MEANS
OF THE RMARS FOR EACH OF THE SEVEN GROUPS (FEMALES ONLY)

GROUP	N	PRETEST	POSTTEST	DIFFERENCE	$\underline{t}$
NONTECH	13	54.54	52.54	2	.6
TECH 1700	5	47	43.6	3.4	.79
TECH 1840	13	47.69	46	1.69	.71
ELEM ED	31	58.06	57.45	.61	.25
MATH ED	7	31.71	32.43	-0.72	-.6
GRAD	14	61.14	57.79	3.35	1.09
CONTROL	14	73.93	73.79	.14	.06

2. The RMARS scores between pre- and posttesting decreased in all of the groups except the Mathematics Education Group, whose RMARS scores increased nonsignificantly.

The Mathematics Education Group was unique with respect to the way in which the mathematical content was presented. Instead of concentrating on the learning of mathematics, the emphasis was on the ways of presenting the material. This format is in sharp contrast to the other mathematics-related courses that these students have taken.

III. CORRELATION OF THE RMARS AND THE SIX BACKGROUND AND EXPERIENTIAL FACTORS

One of this study's goals was to determine whether math anxiety correlates with the six background and experiential factors: (1) mathematics background, (2) mathematics achievement, (3) mathematics performance, (4) mathematics avoidance, (5) self-rating of mathematics ability, and (6) self-rating of mathematics anxiety. Several Pearson product moment correlation coefficients were calculated to compare the RMARS with these six background and experiential factors. The following null hypothesis was tested:

H₀₆: The correlation coefficients are equal to zero.

For each student in the study the following data were available: pretest RMARS scores, highest level of mathematics course successfully completed, lapse of time since last successfully completed mathematics course, the self-rating of mathematics ability on a scale from 1 (terrible) to 10 (excellent), and the self-rating of mathematics anxiety on a scale from 1 (highly anxious) to 10 (not anxious). In addition, the grade received in current mathematics-related course was available (except for Control Group members, who were not taking a mathematics

course). Finally, the score on the ACT mathematics subtest was available for all students except those in the Graduate Students Group, who are not required to have their ACT scores on their permanent records.

Six Pearson product moment correlation coefficients were calculated for the Nontechnical Majors Group, the Technical Majors Group enrolled in Mathematics 1700, the Technical Majors Group enrolled in Mathematics 1840, the Elementary Education Group, and the Mathematics Education Group. Five Pearson product moment correlation coefficients were calculated for the Graduate Students Group and the Control Group. Correlation matrices are presented in Tables 9, 10, and 11. Tables 12, 13, and 14 show the mean of the six background and experiential factors for the groups as a whole, by male, and by female.

Results of the Correlational Analysis

In 90 of the 104 correlations, RMARS correlated as anticipated with the six background and experiential factors. As expected, RMARS generally correlated negatively with five of them--mathematics background, mathematics achievement, mathematics performance, self-rating of mathematics ability, and self-rating of mathematics anxiety; and positively with one of them--mathematics avoidance. Specifically, as an individual had a higher level of math anxiety as measured by the RMARS, that individual could be expected to have successfully completed only lower level mathematics courses, have a lower score on the ACT mathematics subtest, have a poorer grade in a mathematics-related course, have more likely a near-"terrible" self-rating of mathematics ability, and have more likely a near-"high" self-rating of mathematics anxiety. Furthermore, the higher the level of math anxiety, the longer the time lapse since the last successful completion of a mathematics course.

TABLE 9

CORRELATIONAL MATRIX FOR THE VARIABLES SHOWN IN THE TABLE AND RMARS SCORES FOR GROUPS SHOWN

VARIABLE	GROUP						
	NONTECH	TECH 1700	TECH 1840	ELEM ED	MATH ED	GRAD	CONTROL
BACKGROUND	-.342	-.079	-.212	-.353 *	-.318	-.766 **	-.386 *
ACHIEVEMENT	-.356	-.179	-.076	-.474 **	-.234	-----	-.46 *
PERFORMANCE	-.206	.112	.012	-.127	-.838 **	-.618 **	-----
AVOIDANCE	.268	.127	.17	.047	.002	.592 **	.224
ABILITY	-.611 **	-.552 **	-.312 *	-.58 **	-.531 *	-.886 **	-.546 **
ANXIETY	-.53 **	-.104	-.369 **	-.437 **	-.524 *	-.857 **	-.58 *

* Significant at .05 level

** Significant at .01 level.

TABLE 10

CORRELATIONAL MATRIX FOR THE VARIABLES SHOWN IN THE
TABLE AND RMARS SCORES FOR MALES IN GROUPS SHOWN

VARIABLE	GROUP				
	NONTECH	TECH 1700	TECH 1840	MATH ED	CONTROL
BACKGROUND	-.515	-.327	-.268	-.57	-.629 *
ACHIEVEMENT	-.307	-.491 *	-.147	-.209	-.768 **
PERFORMANCE	-.768 *	.229	-.037	-.919 **	-----
AVOIDANCE	-.31	.168	.166	-.054	.798 **
ABILITY	-.235	-.246	-.331 *	-.425	-.775 **
ANXIETY	-.38	.159	-.33 *	-.077	-.111

* Significant at .05 level

** Significant at .01 level.

TABLE 11

CORRELATIONAL MATRIX FOR THE VARIABLES SHOWN IN THE
TABLE AND RMARS SCORES FOR FEMALES IN GROUPS SHOWN

VARIABLE	GROUP						
	NONTECH	TECH 1700	TECH 1840	ELEM ED	MATH ED	GRAD	CONTROL
BACKGROUND	-.25	.579	.313	-.353 *	.555	-.789 **	-.362
ACHIEVEMENT	-.382	.574	.134	-.474 **	-.369	-----	-.27
PERFORMANCE	-.048	-.097	.297	-.127	.429	-.649 **	-----
AVOIDANCE	.658 **	.08	UNDEFINED	.047	-.586	.617 **	.257
ABILITY	-.705 **	-.925 **	-.344	-.58 **	-.017	-.893 **	-.494 *
ANXIETY	-.585 *	-.764 *	-.42	-.437 **	-.219	-.856 **	-.813 *

* Significant at .05 level

** Significant at .01 level.

TABLE 12

MEANS OF THE VARIABLES SHOWN IN THE TABLE FOR GROUPS SHOWN

VARIABLE	GROUP						
	NONTECH	TECH 1700	TECH 1840	ELEM ED	MATH ED	GRAD	CONTROL
BACKGROUND	4.95	6.24	8.62	5.68	16.08	6.4	5.38
ACHIEVEMENT	17.4	18.82	21.77	16.03	24.62	-----	17.71
PERFORMANCE	2.73	3.06	2.7	3.27	3.27	3.37	-----
AVOIDANCE	7.93	1.85	1.77	2.32	1.77	35.43	5.1
ABILITY	5.9	6.76	7.26	5.97	7.85	5.17	5
ANXIETY	5.8	6.12	5.74	5.42	8	4.93	4.38

Note: Background ranged from 1 (general mathematics) to 21 (9 mathematics courses beyond Mathematics 1840)

Achievement ranged from 7 to 34

Performance ranged from 0 (F) to 4 (A)

Avoidance ranged from 1 quarter (previous quarter) to 90.5 quarters (about 22 years)

Ability ranged from 1 (terrible) to 10 (excellent)

Anxiety ranged from (highly anxious) to 10 (not anxious)

TABLE 13
MEANS OF THE VARIABLES SHOWN IN THE TABLE
FOR MALES IN GROUPS SHOWN

VARIABLE	GROUP				
	NONTECH	TECH 1700	TECH 1840	MATH ED	CONTROL
BACKGROUND	5	6.42	8.52	15.33	5.2
ACHIEVEMENT	17.71	19.92	21.88	24.17	18.8
PERFORMANCE	2.86	3.13	2.66	2.67	-----
AVOIDANCE	7.29	1.42	2.03	2	7
ABILITY	5.86	7.08	7.33	7.33	5.1
ANXIETY	5.57	5.75	5.33	6.67	5.5

Note: Background ranged from 1 (general mathenatics) to 21 (9 mathematics courses beyond Mathematics 1840)
 Achievement ranged from 7 to 34
 Performance ranged from 0 (F) to 4 (A)
 Avoidance ranged from 1 quarter (previous quarter) to 90.5 quarters (about 22 years)
 Ability ranged from 1 (terrible) to 10 (excellent)
 Anxiety ranged from 1 (highly anxiuos) to 10 (not anxious)

TABLE 14

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

VARIABLE	GROUP						
	NONTECH	TECH 1700	TECH 1840	ELEM ED	MATH ED	GRAD	CONTROL
BACKGROUND	4.92	5.8	8.92	5.68	16.71	6.5	5.5
ACHIEVEMENT	17.23	18	21.46	16.03	25	-----	16.93
PERFORMANCE	2.65	2.9	2.81	3.27	3.79	3.39	-----
AVOIDANCE	8.27	2.9	1	2.32	1.57	34.64	3.75
ABILITY	5.92	6	7.08	5.97	8.29	5.18	4.93
ANXIETY	5.92	7	7	5.42	9.14	4.86	3.57

Note: Background ranged from 1 (general mathematics) to 21 (9 mathematics courses beyond Mathematics 1840)

Achievement ranged from 7 to 34

Performance ranged from 0 (F) to 4 (A)

Avoidance ranged from 1 quarter (previous quarter) to 90.5 quarters (about 22 years)

Ability ranged from 1 (terrible) to 10 (excellent)

Anxiety ranged from 1 (highly anxious) to 10 (not anxious)

Fourteen of the 104 correlations took an unexpected direction; these correlations, however, were not statistically significant. Thirteen of the fourteen correlations occurred in the Technical Majors Groups and the Mathematics Education Majors Group--the more rigorous mathematics-related courses--five on the factor of mathematics performance, two on mathematics avoidance, two on mathematics achievement (females only), three on mathematics background (females only), and one on self-rating of mathematics anxiety.

Groups as a Whole. A strong pattern of significant correlations emerged for the factors of self-rating of mathematics ability and self-rating of mathematics anxiety. The other correlations were not significant for more than three of the groups. Interestingly, the Graduate Students Group significantly correlated with all the factors that they were measured on, and the Control Group significantly correlated with all the factors that they were measured on except mathematics avoidance. In particular, for the groups as a whole, the RMARS correlated negatively with significance at the .05 level with:

1. self-rating of mathematics ability in all groups;
2. self-rating of mathematics anxiety in all but the Technical Majors enrolled in Mathematics 1700;
3. mathematics background in the Elementary Education Majors (all female), the Graduate Students (all female except one male), and the Control Group;
4. mathematics achievement in the Elementary Education Group (all female) and the Control Group; and
5. mathematics performance in the Mathematics Education Majors Group and Graduate Students Group (all female except one male).

RMARS correlated positively with significance at the .05 level as an indicator of mathematics avoidance for the Graduate Students.

Males. For the males, no clear pattern of significant correlations emerged. No correlation was significant for more than two of the groups of males. (It should be noted again that the Elementary Education Majors and the Graduate Students could not be included in this analysis because they had too few males.) Interestingly, the Control Group significantly correlated with all the factors they were measured on except self-rating of mathematics anxiety. In particular, the RMARS correlated negatively with significance at the .05 level with:

1. self-rating of mathematics ability in the Technical Majors enrolled in Mathematics 1840 and the Control Group;
2. self-rating of mathematics anxiety in the Technical Majors enrolled in Mathematics 1840;
3. mathematics background in the Control Group;
4. mathematics achievement in the Technical Majors enrolled in Mathematics 1700 and the Control Group;
5. mathematics performance in the Nontechnical Majors Group and the Mathematics Education Group.

RMARS correlated positively with significance at the .05 level as an indicator of mathematics avoidance in the Control Group.

Females. For the females, five of the seven correlations were significant for self-rating of mathematics ability and self-rating of mathematics anxiety. The other correlations were not significant for more than two of the groups of females. Interestingly, the Graduate Students Group significantly correlated with all the factors they were

measured on. In particular, the RMARS correlated negatively with significance at the .05 level with:

1. self-rating of mathematics ability in the Nontechnical Majors, the Technical Majors enrolled in Mathematics 1700, the Elementary Education Majors, the Graduate Students Group, and the Control Group;
2. self-rating of mathematics anxiety in all but the Technical Majors enrolled in Mathematics 1840 and the Mathematics Education Majors;
3. mathematics background in the Elementary Education Majors and the Graduate Students Group;
4. mathematics achievement in the Elementary Education Majors; and
5. mathematics performance in the Graduate Students Group.

RMARS correlated positively with significance at the .05 level as an indicator of mathematics performance for the Nontechnical Majors and the Graduate Students Group.

Discussion of the Results

In summary, higher levels of math anxiety are associated with six factors, briefly listed here and then discussed in more detail.

1. mathematics background
2. mathematics achievement
3. mathematics performance
4. mathematics avoidance
5. self-rating of mathematics ability
6. self-rating of mathematics anxiety

1. Higher levels of math anxiety are associated with the successful completion of the lower level mathematics courses,

- (a) for the group, as a whole, and males within the Control Group;
- (b) for the group, as a whole, and for females within the Graduate Students Group (only one male); and
- (c) for the total Elementary Education Majors Group (all females).

This supports what has been suggested in the literature (Betz, 1978; Hendel, 1980). Hendel found a correlation of $-.31$ between scores on the MARS and number of semesters of high school math in a sample of adult women enrolled in a math anxiety treatment program. Betz found statistically significant correlations ranging from $.19$ to $.43$ between math anxiety and number of years of high school math in three groups of freshmen and sophomores enrolled in mathematics or psychology courses.

2. Higher levels of math anxiety are associated with lower ACT mathematics subtest scores,

- (a) for the group, as a whole, and for males within the Control Group;
- (b) for the total Elementary Education Majors Group (all females); and
- (c) for the males within the Technical Majors enrolled in Mathematics 1700.

Betz (1978) also found a moderate relationship between math anxiety and ACT Mathematics scores. She found correlations that ranged from $.17$ to $.42$.

3. Higher levels of math anxiety are associated with lower grade received in current mathematics-related course,

- (a) for the group, as a whole, and for males within the Mathematics Education Majors;

(b) for the group, as a whole, and for females within the Graduate Students Group (all females except for one male); and

(c) for males within the Nontechnical Majors Group.

Betz (1978), Dreger and Aiken (1957), Hendel (1980), Richardson and Suinn (1972), and Dew (1982) all found similar results.

4. Higher levels of math anxiety are associated with longer lapse of time since last successfully completed mathematics course,

(a) for the group, as a whole, and females in the Graduate Students Group;

(b) for males within the Control Group; and

(c) for females within the Nontechnical Majors Group.

5. Higher levels of math anxiety are associated with lower self-rating of mathematics ability,

(a) for the groups, as a whole, and males, and females within each group in the Control Group;

(b) for the group, as a whole, and males within the Technical Majors enrolled in Mathematics 1840;

(c) for the groups, as a whole, and females within each group in the Technical Majors enrolled in Mathematics 1700, the Nontechnical Majors, and the Graduate Students Group (only one male);

(d) for the group, as a whole, in the Mathematics Education Group; and

(e) for the total Elementary Education Majors Group (all females).

6. Higher levels of math anxiety are associated with higher self-rating of mathematics anxiety.

- (a) for the group, as a whole, and males within the Technical Majors enrolled in Mathematics 1840;
- (b) for the groups, as a whole, and females within each group, in the Nontechnical Majors Group, the Graduate Students Group (all females except one male) and the Control Group;
- (c) for the group, as a whole, in the Mathematics Education Majors Group;
- (d) for the total Elementary Education Majors Group (all female); and
- (e) for females within the Technical Majors enrolled in Mathematics 1700.

IV. SUMMARY

This chapter presents and discusses the results of the analysis of the Revised Mathematics Anxiety Rating Scale, the changes from pre- to posttest RMARS scores, and the correlation coefficients relating the RMARS to the six background and experiential factors.

CHAPTER V

SUMMARY, CONCLUSIONS, AND SUGGESTIONS

The purpose of this study was to investigate the prevalence and intensity of math anxiety in college students (as a whole, by major, and by sex), to determine the stability of math anxiety over time, and to determine those background and experiential factors related to the occurrence of math anxiety in college students. Data gathered on college students in mathematics, education, and English classrooms were utilized. Students completed two instruments:

1. the revised version of the Mathematics Anxiety Rating Scale (RMARS), a scale developed by Plake and Parker (1982) which was designed to provide an efficient index of math anxiety, and
2. the Student Information Questionnaire (SIQ), developed by the investigator to measure the factors of college major, sex, mathematics background, mathematics achievement, mathematics performance, mathematics avoidance, self-rating of mathematics ability, and self-rating of mathematics anxiety.

I. ANSWERS TO RESEARCH QUESTIONS

As a whole, math anxiety was not very prevalent in the seven groups of college students participating in the study during Winter Quarter, 1985, at The University of Tennessee, Knoxville. Math anxiety was most intense in three groups: Elementary Education Majors, Graduate Students, and Control Group. However, even the Control Group, whose pretest RMARS

scores were the highest of all of the groups, were on the average only "frightened" by the items "a little" to "a fair amount" of the time. This is also the case for the Graduate Students and the Elementary Education Majors. The responses of the Nontechnical Majors and the Technical Majors enrolled in Mathematics 1840 averaged "a little." And the average responses for the Technical Majors enrolled in Mathematics 1700 and the Mathematics Education Majors were "not at all." Also, math anxiety was not any more prevalent in one sex than another.

Math anxiety was fairly stable over a short period of time (seven weeks). Only the math anxiety of both of the Technical Majors Groups significantly decreased.

Self-rating of mathematics ability was the factor that was most related to the occurrence of math anxiety for all of the groups. However, for the Elementary Education Majors, the Graduate Students, and the Control Group, all of the factors were related to the occurrence of their math anxiety.

The results suggested these answers to the research questions motivating this study, briefly listed here and then discussed in more detail:

1. Math anxiety is related to choice of college major.
2. Males and females do not differ in their math anxiety levels.
3. Math anxiety levels change very little over a short time interval.
- 4a. Math anxiety is related to mathematics background in the Elementary Education Majors, the Graduate Students, and the Control Group.
- 4b. Math anxiety is related to mathematics achievement in the Elementary Education Majors, the Control Group, and the males in the Technical Majors enrolled in Mathematics 1700.

- 4c. Math anxiety is related to mathematics performance in the Mathematics Education Majors, the Graduate Students, and the males in the Nontechnical Majors Group.
- 4d. Math anxiety is related to mathematics avoidance in the Graduate Students Group, the females in the Nontechnical Majors Group, and the males in the Control Group.
- 4e. Math anxiety is related to self-rating of mathematics ability in all seven groups.
- 4f. Math anxiety, as measured by the RMARS, is related to self-rating of mathematics anxiety in all of the groups, except the males in the Technical Majors enrolled in Mathematics 1700.

1. Math anxiety is related to choice of college major. The math anxiety of the Control Group (not enrolled in any mathematics courses) was higher than the math anxiety of the Graduate Student Group, which was higher than the Elementary Education Majors, followed by the Nontechnical Majors, the Technical Majors enrolled in Mathematics 1840, the Technical Majors enrolled in Mathematics 1700, and finally the group with the least math anxiety—the Mathematics Education Group. So students in the less mathematically rigorous groups had more math anxiety than students in the more mathematically rigorous groups. Three of the differences were significant. The math anxiety of the Control group was significantly higher ($F = 4.98$, $p < .01$) than that of the Technical Majors (both) and of the Mathematics Education Majors. These groups had the best mathematics backgrounds, highest ACT mathematics subtest scores, and shortest lapse of time since last successful completion of a mathematics course.

2. Males and females do not differ in their math anxiety levels. By comparing males and females in the same group, the number of mathematics

courses previously completed was actually being controlled, as the prerequisites for each course had to be met by all students, regardless of sex.

3. Math anxiety levels change very little over a short time interval. The math anxiety of all the groups, except the Mathematics Education Majors, slightly decreased from the beginning of the quarter to a point seven weeks later, significantly for the Technical Majors enrolled in Mathematics 1700 ($\underline{t} = 2.24$, $p < .05$) and Mathematics 1840 ($\underline{t} = 2.04$, $p < .05$) and for males within the Technical Majors enrolled in Mathematics 1700 ($\underline{t} = 2.11$, $p < .05$) and Mathematics 1840 ($\underline{t} = 1.92$, $p < .05$). The math anxiety of the Mathematics Education Majors (had the lowest levels of math anxiety) increased nonsignificantly.

4. The following relationships were found between math anxiety and the six background and experiential factors:

(a) Math anxiety is related to mathematics background in the Elementary Education Majors ($\underline{r} = -.353$, $p < .05$), the Graduate Students ($\underline{r} = -.766$, $p < .01$), and the Control Group ($\underline{r} = -.386$, $p < .05$). The higher the level of math anxiety, as measured by the RMARS, the lower the level of mathematics course successfully completed. These three groups had poor backgrounds in mathematics, on the average completing only up through high school algebra.

(b) Math anxiety is related to mathematics achievement in the Elementary Education Majors ($\underline{r} = -.474$, $p < .01$), the Control Group ($\underline{r} = -.46$, $p < .05$), and the males in the Technical Majors enrolled in Mathematics 1700 ($\underline{r} = -.491$, $p < .05$). The higher the level of math anxiety, as measured by the RMARS, the lower the score on the ACT mathematics subtest. The scores of the Elementary Education Majors and the

Control Group were the lowest of all of the groups, with an average of 16.87.

(c) Math anxiety is related to mathematics performance in the Mathematics Education Majors ($\underline{r} = -.838$, $p < .01$), the Graduate Students ($\underline{r} = -.618$, $p < .01$), and the males in the Nontechnical Majors ($\underline{r} = -.768$, $p < .05$). The greater the math anxiety, as measured by the RMARS, the lower the grade received in the current mathematics-related course.

(d) Math anxiety is related to mathematics avoidance in the Graduate Students Group ($\underline{r} = .592$, $p < .01$), the females in the Nontechnical Majors Group ($\underline{r} = .658$, $p < .01$), and the males in the Control Group ($\underline{r} = .798$, $p < .01$). The greater the math anxiety, as measured by the RMARS, the longer the lapse of time since they last successfully completed a mathematics course. These groups had not successfully completed a mathematics course for at least two years, with the Graduate Students Group not being enrolled in a mathematics course for the longest period of time, an average of eight and one-half years.

(e) Math anxiety is related to self-rating of mathematics ability in all seven groups:

1. Nontechnical Majors ($\underline{r} = -.611$, $p < .01$),
2. Technical Majors enrolled in Mathematics 1700
($\underline{r} = -.552$, $p < .01$),
3. Technical Majors enrolled in Mathematics 1840
($\underline{r} = -.312$, $p < .05$),
4. Elementary Education Majors ($\underline{r} = -.58$, $p < .01$),
5. Mathematics Education Majors ($\underline{r} = -.531$, $p < .05$),
6. Graduate Students ($\underline{r} = -.886$, $p < .01$), and
7. Control Group ($\underline{r} = -.546$, $p < .01$).

The greater the math anxiety, the lower the self-rating of mathematics ability.

(f) Math anxiety, as measured by the RMARS, is related to self-rating of mathematics anxiety in all of the groups, except the Technical Majors enrolled in Mathematics 1700:

1. Nontechnical Majors ($r = -.53$, $p < .01$),
2. Technical Majors enrolled in Mathematics 1840
($r = -.369$, $p < .01$),
3. Elementary Education Majors ($r = -.437$, $p < .01$),
4. Mathematics Education Majors ($r = -.524$, $p < .05$),
5. Graduate Students ($r = -.857$, $p < .01$), and
6. Control Group ($r = -.58$, $p < .01$).

The greater the math anxiety, as measured by the RMARS, the greater the self-rating of mathematics anxiety.

II. CONCLUSIONS

1. Math anxiety showed relatively little relationship to mathematics performance. Of the 16 correlations between math anxiety and mathematics performance, five (those in the Technical Majors Groups and the Mathematics Education Majors Group) indicated that higher levels of math anxiety were associated with higher mathematics-course grades. Thus improving mathematics performance will require programs that do more than reduce math anxiety. In fact, moderate levels of math anxiety may actually improve one's mathematics performance in those groups.

2. Math anxiety showed a moderate relationship to mathematics background, mathematics achievement, and mathematics avoidance. It should be noted that the relationship is least pronounced in the

Technical Majors Groups and the Mathematics Education Majors Group, whose overall math anxiety was not very high, and who had relatively strong backgrounds, high achievement scores (ACT mathematics subtest), and no prolonged avoidance behaviors. The relationship is most pronounced in the Elementary Education Majors Group, the Graduate Students Group, and the Control Group, whose prior mathematics background and achievement are inadequate and who have avoided taking mathematics courses. Because the Graduate Students Group was mainly composed of re-entry students, such students would appear to benefit most from treatment of math anxiety.

3. The students with the more technical majors generally displayed lower levels of math anxiety than the students with the less technical majors. Also, the higher one's level of math anxiety, the lower one's self-rating of mathematics ability. Thus, math anxiety appears to be related to inherent mathematical abilities of students.

4. The RMARS seemed to adequately measure one's level of math anxiety as perceived by oneself for all groups except for the Technical Majors enrolled in Mathematics 1700. Therefore the data does not support the notion that the RMARS is an inadequate measure of math anxiety for students taking calculus.

5. Sex-related differences in math anxiety may exist, but they are probably much smaller than has been suggested previously. This is probably due in part to this study's comparison of males and females with similar mathematics backgrounds and experiences. However, more hopefully, it might represent a decrease in sex-related differences over the past decade.

6. Richardson and Suinn (1972) reported a test-retest reliability of .85 for the MARS, Suinn, Edie, Nicoletti, and Spinelli (1972) reported

one of .78, while Dew (1982) reported one of .87. The correlation between the RMARS and the MARS was .97 (Plake and Parker, 1982). Since the test-retest reliability of the MARS is relatively high and the correlation between the RMARS and the MARS is relatively high, it follows that the test-retest reliability of the RMARS is relatively high. Since there existed significant differences in math anxiety between the Control Group and both Technical Majors Groups, it is reasonable to conclude that the reduction of math anxiety in the Technical Majors Groups could be attributed primarily to the unique elements of these groups: course content, prerequisites, and position in the sequence. Specifically, the content of both the Technical Majors Groups was directly related to Calculus. Prerequisites for the Technical Majors Groups are identical and are as follows: (1) two years of high school algebra, and (2) one year of high school geometry. The corequisite for the Technical Majors Groups is one half year of high school trigonometry. Mathematics 1700 is offered for students who intend to take Mathematics 1840 but score less than 26 on the ACT mathematics subtest. Both Mathematics 1700 and Mathematics 1840 are beginning courses in a six-quarter Calculus sequence. As a result, the following conclusion was made. The unique elements of the Technical Majors Groups, in and of themselves, effectively reduced math anxiety.

III. SUGGESTIONS FOR FURTHER RESEARCH

1. There is a need to identify the reasons for the disparity of male and female enrollment in the Technical Majors. Since males and females did not differ in their math anxiety levels, attention should be focused on cultural factors, not only at the college level, but especially at the junior-high school level (before the differential course-taking by sex begins).

2. There is a need to conduct long-term projects in which math anxiety is measured on a regular basis (i.e. every quarter) for a period of years. In particular, a study should be conducted to plot the math anxiety of the Elementary Education Majors and the Mathematics Education Majors while they are in college as students and after graduation while they are teaching mathematics. Furthermore, the math anxiety of these "teachers" could be compared to the math anxiety of their students. Also, a study should be conducted to track the Technical Majors Groups to determine whether their reduction in math anxiety remained stable over a longer time period.

3. There is a need to identify other background and experiential factors effecting the levels of math anxiety, including amount of time spent in studying mathematics outside of the classroom.

4. There is a need to analyze the RMARS by item to determine whether there is a common subset of items to which students respond with "much" and "very much" as a whole, by major, and by sex.

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APPENDICES

APPENDIX A

MATERIALS USED IN THE STUDY

INFORMATION ABOUT THE USE OF A REVISED VERSION

OF THE MATHEMATICS ANXIETY RATING SCALE

AT THE UNIVERSITY OF TENNESSEE

During the Winter Quarter, 1985, C & I 3752, C & I 5610, Math 1540, Math 1700, Math 1840, Math 2110-20-30, and English 1020, will be involved in a research study about math anxiety. The aim of this research is to gain insights into the study of math and math anxiety. Each person participating in the study will be required to complete a revised version of the Mathematics Anxiety Rating Scale (RMARS) and a student information questionnaire. The RMARS is a twenty-four item scale on which you state how anxious you feel concerning various mathematical situations. Also, each person participating in the study authorizes the University of Tennessee to release his/her ACT-mathematics score to the researcher.

As a result of your participation in the study, you will probably have a greater understanding of your own feelings and attitudes regarding the study of mathematics. It is reasonable to assume that you will not experience any negative effects from the study.

Participation in the study is voluntary. Refusal to participate will not involve any penalty. Also, you may discontinue participation at any time during the quarter without any penalty.

No student will be identified in any way in the publication of the research. All of your responses will be held in confidence by the researcher and your responses will have no effect on your grades. If you have any questions regarding the study, please contact Patty Letsinger, Ayres Hall, 403 C.

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

NAME: _____

SOCIAL SECURITY NUMBER: _____

DATE: _____

Please check the appropriate blank:

I am 18 years of age or older _____

I am under 18 years of age _____

NAME _____

Total Score _____

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 math course.	☐	☐	☐	☐	☐
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.	☐	☐	☐	☐	☐
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.	☐	☐	☐	☐	☐
TOTAL	_____	_____	_____	_____	_____

	Not at all	A little	A fair amount	Much	Very much
Waiting to get a math test returned in which you expected to do poorly.	☐	☐	☐	☐	☐
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 the tables in the back of a math book.	☐	☐	☐	☐	☐
Being told how to interpret probability statements.	☐	☐	☐	☐	☐
TOTAL	—	—	—	—	—
Total Score					

STUDENT INFORMATION QUESTIONNAIRE

Please complete each of the following statements about yourself.

NAME: _____ (please print)
last first middle

SOCIAL SECURITY NUMBER:

SEX: MALE FEMALE

COLLEGE: MAJOR:

Place a check beside each of the courses that you have successfully completed: (with a grade of 'C' or better)

(A) IN JUNIOR HIGH OR
MIDDLE SCHOOL OR
HIGH SCHOOL

(B) IN COLLEGE

GENERAL MATHEMATICS _____
ALGEBRA I _____
GEOMETRY _____
ALGEBRA II _____
TRIGONOMETRY _____
ANALYSIS _____
PRECALCULUS _____
ADVANCED MATH _____
CALCULUS _____

MATH 0150 (TRIG) _____
MATH 1540 (ALGEBRA) _____
MATH 1700 (PRECALCULUS) _____
MATH 1840 (CALCULUS) _____
OTHER (SPECIFY) _____

List all mathematics courses you are enrolled in this quarter:

I last successfully completed (with a grade 'C' or better) a mathematics course:

FALL 1984 _____ SUMMER 1984 _____ SPRING 1984 _____ WINTER 1984 _____
1983 _____ 1982 _____ OTHER (SPECIFY) _____

Place a circle around one number to show how you rate your mathematics ability:

1 2 3 4 5 6 7 8 9 10
TERRIBLE EXCELLENT

Place a circle around one number to show how you rate your anxiety about mathematics:

1	2	3	4	5	6	7	8	9	10
HIGHLY ANXIOUS								NOT ANXIOUS	

Have you ever participated in (or are currently participating in) a math anxiety treatment program? YES NO

Are you repeating this course because you previously received a grade of 'D' OR 'F'? YES NO

APPENDIX B

STATISTICAL DATA

TABLE 15

STATISTICAL DATA — NONTECHNICAL MAJORS (n = 20)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
M	31	43	9	19	3	6.5	7	6
F	49	33	3	17	2	14.5	5	8
M	62	37	3	8	2	1	5	9
M	42	53	2	23	4	22.5	6	3
F	72	54	8	23	4	6.5	5	1
F	37	47	8	17	1	6.5	5	4
F	90	82	4	12	4	10.5	5	1
M	63	54	4	12	2	6.5	5	4
M	48	41	3	14	3	6.5	7	6
F	56	46	5	10	2.5	10.5	8	5
F	32	28	5	23	1	1	8	9
F	37	39	4	20	4	6.5	8	9
F	38	55	4	7	2	6.5	6	6
M	34	24	10	27	4	4	5	8
F	48	38	4	21	3	6.5	4	7
F	35	49	8	23	4	3	9	7
M	92	95	4	21	2	4	6	3
F	97	81	3	19	3	10.5	4	2
F	27	31	4	24	4	6.5	8	9
F	91	100	4	8	0	18.5	2	9

TABLE 16

STATISTICAL DATA -- TECHNICAL MAJORS ENROLLED IN MATHEMATICS 1700 (n = 17)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
M	31	30	8	26	3	1	8	6
F	55	59	8	20	4	1	6	5
M	49	60	5	19	4	1	8	3
M	53	43	5	16	4	1	8	7
F	38	42	5	22	3.5	1	6	7
F	71	54	6	22	2	5	3	5
M	52	42	5	27	4	3	8	8
F	39	29	5	11	3	1	7	10
M	51	40	5	10	1	1	5	5
F	32	34	5	15	2	6.5	8	8
M	28	31	8	21	2	1	6	7
M	26	28	5	26	3.5	1	8	3
M	47	30	8	14	3.5	1	8	1
M	40	36	8	26	2	3	7	9
M	57	43	4	18	3.5	2	6	6
M	46	37	8	16	4	1	7	6
M	59	59	8	20	3	1	6	8

TABLE 17

STATISTICAL DATA -- TECHNICAL MAJORS ENROLLED IN MATHEMATICS 1840 (n = 53)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
F	37	34	9	24	4	1	8	8
M	76	60	9	17	3.5	1	6	4
M	68	52	9	13	1	1	6	1
M	77	69	9	21	4	1	7	7
M	57	43	9	18	1	1	8	7
F	41	45	10	20	1	1	7	10
M	49	48	9	24	3	1	7	2
M	35	36	9	25	3	1	7	10
F	59	71	10	22	2.5	1	6	4
M	35	29	9	25	3.5	1	7	4
F	64	51	9	23	3	1	7	7
F	47	51	9	20	3.5	1	6	5
M	35	33	9	20	3	1	7	4
M	64	66	6	17	0	5	8	4
M	64	53	9	26	4	1	6	3
M	59	53	9	23	3	1	7	5
M	50	37	9	25	2.5	1	7	6
M	50	45	9	13	2.5	1	8	7
M	49	43	10	12	2	1	7	6
M	38	34	9	26	2.5	1	8	6
M	59	65	5	19	3.5	21	6	5
F	54	55	9	24	3	1	8	8
M	30	34	9	25	1	1	10	8

TABLE 17 (continued)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
M	33	40	9	21	2	1	7	6
M	63	42	9	21	3	1	7	5
M	50	49	9	27	4	1	9	4
M	56	51	9	22	2	1	8	6
M	67	60	9	23	2.5	1	7	6
M	52	77	5	27	2	3	7	8
F	29	30	9	25	1	1	8	10
M	36	37	10	25	3	1	7	5
M	62	60	9	22	4	1	9	5
F	45	39	9	24	3	1	7	6
F	57	46	9	17	3	1	4	7
F	47	49	8	26	3.5	1	8	8
M	72	62	8	22	1	4	8	3
M	39	44	9	22	4	1	7	8
M	55	39	5	19	1	6.5	7	9
M	58	55	9	24	2	1	7	5
M	33	35	9	16	2	1	8	5
F	35	44	7	8	3	1	7	5
F	44	39	9	24	3	1	8	7
M	69	72	5	21	3	2	6	3
M	54	50	8	21	3.5	6.5	7	2
M	37	50	9	23	2	1	8	7
M	46	36	9	26	3	1	7	8

TABLE 17 (continued)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
M	52	53	9	21	3	1	8	6
M	44	41	9	27	3	1	8	4
M	65	72	9	27	2	1	4	3
M	37	38	9	23	3.5	1	8	2
F	61	44	9	22	3	1	8	6
M	31	36	9	19	4	1	8	8
M	68	69	9	27	4	1	9	6

TABLE 18

STATISTICAL DATA — ELEMENTARY EDUCATION MAJORS (n = 31)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
F	71	55	4	11	2	2	5	6
F	47	74	3	7	2	6.5	5	5
F	55	43	5	14	3	6.5	7	6
F	64	65	6	6	3.5	3	5	3
F	64	56	5	13	2	1	6	6
F	35	31	9	20	4	1	7	6
F	71	102	4	10	4	6.5	4	7
F	67	72	3	23	3	4	4	3
F	47	39	5	22	4	3	6	8
F	46	52	9	23	4	1	9	10
F	79	61	6	11	3	1	7	7
F	42	48	10	27	4	1	7	5
F	34	28	7	19	4	3	8	8
F	80	69	6	9	4	1	8	5
F	96	99	4	6	4	4	2	1
F	47	53	6	21	4	1	7	8
F	52	44	4	13	3.5	1	6	2
F	60	63	6	21	4	1	6	6
F	59	46	6	17	4	1	6	7
F	40	47	5	19	4	1	8	7
F	56	52	4	22	4	1	5	7
F	75	60	6	17	3	1	5	5
F	76	79	7	18	2.5	2	5	2

TABLE 18 (continued)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
F	82	55	5	16	3	1	5	5
F	56	38	7	10	1	6.5	6	4
F	53	50	7	13	3	3	4	3
F	50	60	5	18	3	1	6	4
F	48	47	6	19	2.5	2	5	7
F	64	73	5	21	3.5	1	6	4
F	43	76	6	14	2	1	7	4
F	41	44	5	17	4	3	8	7

TABLE 19

STATISTICAL DATA — MATHEMATICS EDUCATION MAJORS (n = 13)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
M	36	30	17	20	3	1	7	5
F	30	31	18	29	4	3	9	9
M	81	81	14	20	1	1	7	6
M	51	38	13	24	3	4	7	6
F	31	26	16	26	4	1	8	10
M	53	63	16	34	3	1	7	9
F	24	24	13	26	3	3	8	10
F	32	36	15	21	4	1	8	9
F	28	30	19	26	4	1	9	9
M	35	41	19	30	3.5	1	8	8
F	36	35	15	22	3.5	1	7	7
M	48	63	13	17	2.5	4	8	6
F	41	45	21	25	4	1	9	10

TABLE 20

STATISTICAL DATA -- GRADUATE STUDENTS (n = 15)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS PERFORMANCE	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
F	112	89	4	3	58.5	3	1
F	50	45	5	4	44.5	7	7
F	42	47	10	3.5	30.5	7	4
F	47	42	11	4	6.5	6	8
F	55	52	4	4	49	6	8
F	68	73	4	4	46.5	3	1
F	29	33	11	4	25	8	9
F	66	49	5	3	26.5	4	4
F	91	80	3	2	90.5	1	1
F	44	64	8	3	22	6	8
M	51	51	5	3	46.5	5	6
F	93	84	4	3	38.5	2	1
F	59	42	5	3	14.5	5	5
F	73	79	4	3	18	5	1
F	27	30	13	4	14.5	9.5	10

TABLE 21

STATISTICAL DATA -- CONTROL (n = 24)

SEX	RMARS PRETEST	RMARS POSTTEST	MATHEMATICS BACKGROUND	MATHEMATICS ACHIEVEMENT	MATHEMATICS AVOIDANCE	SELF-RATING OF MATHEMATICS ABILITY	SELF-RATING OF MATHEMATICS ANXIETY
M	66	47	3	19	10.5	3	2
F	102	102	9	12	1	4	2
F	36	38	9	12	1	8	7
M	58	37	5	21	10.5	4	3
F	75	87	4	17	6.5	1	5
F	104	101	4	16	6.5	4	1
F	98	93	4	15	1	4	1
F	53	66	11	23	4	7	5
F	59	49	5	14	1	5	5
M	64	60	2	10	6.5	4	1
M	33	32	12	27	1	8	7
M	42	56	8	22	6.5	5	7
F	86	74	5	22	1	7	3
F	77	83	5	18	1	5	6
M	65	86	2	18	4	4	10
M	45	56	9	20	1	6	8
F	65	44	2	14	10.5	3	3
F	92	93	4	22	10.5	6	1
M	34	38	3	21	4	8	5
F	88	91	4	7	6.5	3	1
M	82	84	4	13	15	5	9
F	60	60	5	19	1	5	2
M	70	57	4	17	11	4	3
F	40	52	6	26	1	7	8

APPENDIX C

HUMAN SUBJECTS APPROVAL

THE UNIVERSITY OF TENNESSEE, KNOXVILLE
KNOXVILLE 37996-0140

OFFICE OF THE VICE PROVOST
FOR RESEARCH

November 6, 1984

AREA 615
TELEPHONE 974 3466

BY HOLT TOWER

Patricia Preston Letsinger
121 Ayres Hall
CAMPUS

Dear Ms. Letsinger:

The project which you submitted entitled, "A Study of the Relationship between Level of Mathematics Anxiety and Selected Cognitive Variables," CRP #A-283, has been reviewed.

This project comes within the guidelines which permit me to certify that the project is exempt from review by the Committee on Research Participation.

The responsibility of the project director includes the following:

1. Prior approval from the Dean for Research 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,



Marla Peterson
Dean for Research

SCW

cc: Dr. C. W. Minkel, Acting Vice Provost for Research
Dr. T. W. Hipple
Dr. Donald J. Dessart
Dr. Janet R. Handler

APPENDIX D

CODING FOR MATHEMATICS BACKGROUND

STUDENT INFORMATION QUESTIONNAIRE

Please complete each of the following statements about yourself.

NAME: _____ (please print)
last first middle

SOCIAL SECURITY NUMBER: _____

SEX: MALE _____ FEMALE _____

COLLEGE: _____ MAJOR: _____

Place a check beside each of the courses that you have successfully completed: (with a grade of 'C' or better)

(A) IN JUNIOR HIGH OR
MIDDLE SCHOOL OR
HIGH SCHOOL

(B) IN COLLEGE

GENERAL MATHEMATICS	1
ALGEBRA I	2
GEOMETRY	3
ALGEBRA II	4
TRIGONOMETRY	8
ANALYSIS	9
PRECALCULUS	9
ADVANCED MATH	9
CALCULUS	11

MATH 0150 (TRIG)	<u>8</u>
MATH 1540 (ALGEBRA)	<u>5</u>
MATH 1700 (PRECALCULUS)	<u>10</u>
MATH 1840 (CALCULUS)	<u>12</u>
OTHER (SPECIFY)	
MATH 1550	<u>6</u>
MATH 1560	<u>7</u>

List all mathematics courses you are enrolled in this quarter:

I last successfully completed (with a grade 'C' or better) a mathematics course:

FALL 1984 _____ SUMMER 1984 _____ SPRING 1984 _____ WINTER 1984 _____
1983 _____ 1982 _____ OTHER (SPECIFY) _____

Place a circle around one number to show how you rate your mathematics ability:

1	2	3	4	5	6	7	8	9	10
TERRIBLE								EXCELLENT	

Place a circle around one number to show how you rate your anxiety about mathematics:

1	2	3	4	5	6	7	8	9	10
HIGHLY ANXIOUS								NOT ANXIOUS	

Have you ever participated in (or are currently participating in) a math anxiety treatment program? YES _____ NO _____

Are you repeating this course because you previously received a grade of 'D' OR 'F'? YES NO

VITA

Patricia (Patty) Ann Preston was born in Washington, D.C. on November 17, 1953, and attended public schools in Charleston, West Virginia, Atlanta, Georgia, St. Louis, Missouri, Arlington, Virginia, and Dyersburg, Tennessee. She attended Lambuth College, the University of Tennessee, Martin, and Jackson State Community College, and was graduated from the University of Tennessee, Knoxville, with a B.S. degree in Mathematics Education in 1974. She was a graduate teaching assistant in the Mathematics Department at the University of Tennessee, Knoxville, and received her Master of Mathematics degree in 1975 from the University of Tennessee, Knoxville.

From 1975 to 1977, she was a mathematics teacher at Seven Hills Independent Schools, Cincinnati, Ohio, where she taught at all levels from eighth through eleventh grade.

In 1978, she entered the Graduate School of the University of Tennessee, Knoxville, where she was a graduate teaching assistant in the Mathematics Department. She received the Doctor of Philosophy degree with a major in Mathematics Education in June 1986.

She is a member of Pi Lambda Theta honorary society, National Council of Teachers of Mathematics, Association for Women in Mathematics, and the Mathematical Association of America.

Patty is married to Wade C. Letsinger, and they have three children, Robin Michele, 9, Michael Todd, 7, and Ann Marie, 1.