

A FACTOR-ANALYTIC STUDY OF MATHEMATICS ANXIETY,

by

Jeanne Lan Ling,

Dissertation submitted to the Graduate Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

in

Curriculum and Instruction

APPROVED:

Larry J. Weber, Chairman

Robert B. Frary

Robert M. Todd

Harold W. Mick

Alvin M. Pettus

March, 1982

Blacksburg, Virginia

ACKNOWLEDGEMENTS

I wish to thank the members of my committee for their help and advice during all stages of this study. I am especially grateful to Dr. Larry J. Weber, the chairman of my committee, for his advice and patience. I wish to express my sincere appreciation to Dr. Robert B. Frary, for his interest, enthusiasm and constructive guidance throughout the development of this study. I appreciate the efforts of Dr. Robert M. Todd and Dr. Harold W. Mick particularly in the early stages of my study. I also wish to thank Dr. Alvin M. Pettus for his interest in this study.

Appreciation is expressed to Dr. C. Wayne Patty, Head of the Mathematics Department, Virginia Polytechnic Institute and State University, for his interest and help in the study. Appreciation is also extended to the faculty, staff and students who participated in the study of the Mathematics Department.

Finally, I wish to express my deep gratitude to my husband, Dr. Chih-Bing Ling and to our two sons, Drs. Jung Ling and Kang Ling, for their constant encouragement.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	ii
LIST OF TABLES	vi
LIST OF FIGURES	vii
 1. THE PROBLEM	 1
Overview of Procedure	4
Instrumentation	5
Subjects	7
Administration of Instruments	7
Factor Analysis	8
2. LITERATURE REVIEW	9
3. PROCEDURES	15
Instrumentation	15
The Adjective Check List	15
Short-Form Dogmatism Scale	19
Test Anxiety Inventory	20
Mathematics Anxiety Scale	20
Attitude Toward Success in Mathematics Scale	20
Effectance Motivation in Mathematics Scale	20
Usefulness of Mathematics Scale	20
Confidence in Learning Mathematics Scale and Personal Data	20

TABLE OF CONTENTS, continued

	Page
Subjects	21
Administration of Instruments	23
Data Analysis	24
4. FINDINGS	27
DISCUSSION	27
SUMMARY	48
CONCLUSIONS	49
RECOMMENDATIONS	50
REFERENCES	53
APPENDICES	57
A. Matrix of Intercorrelations Among Variables of the Study	58
B. Instruments	
1. The Adjectives Check List	60
2. Short-Form Dogmatism Scale	63
3. Test Anxiety Inventory	65
4. Mathematics Anxiety Scale	67
5. Attitude Toward Success in Mathematics Scale . .	68
6. Effectance Motivation in Mathematics Scale . .	69
7. Usefulness of Mathematics Scale	71
8. Confidence in Learning Mathematics	72
9. Personal Data	73

TABLE OF CONTENTS, continued

	Page
VITA	75
ABSTRACT	

LIST OF TABLES

Table	Page
1. Number of Subjects in Various Personal Data Categories	22
2. Reliability Estimates	28
3. Number of Students, Means, Standard Deviation of Mathematics Attitude Scales and Personality Variables	30
4. Number of Students, Means, Standard Deviations of Six Personal Data	34
5. Varimax Rotated Factor Matrix of 28 Variables for Six Factor Loadings	37
6. Factor One - Personal Effectiveness	38
7. Factor Two - Assertiveness	40
8. Factor Three - Mathematics Anxiety	41
9. Factor Four - Outgoingness	43
10. Factor Five - Success	44
11. Factor Six - Dogmatism	45
12. Correlation Coefficients Between Personal Data and Factor Scores	46

LIST OF FIGURES

Figure	Page
1. General Research Design	26
2. Graph of Eigenvalues for Six Factors	36

Chapter 1

THE PROBLEM

The importance of mathematics as a part of daily life has long been recognized in our society. Students from kindergarten through high school have always been required to take mathematics, and it has traditionally been part of the core curricula at most American colleges and universities. Aptitude in mathematics is additionally often a prerequisite for admission into graduate and professional schools, thus the inclusion of a mathematics component in standard graduate admission tests.

At the same time that we have acknowledged the importance of mathematics ability to daily living and have recognized it as a discriminating predictor of success in higher education, we have known that for some students, learning to manipulate numerical symbols with the ease and fluency with which they manipulate verbal symbols presents problems. In learning mathematics, many students may suffer anxiety, feeling that mathematics is something they "just can't do." When faced with a numerical problem, they respond with panic, muddled thinking, an inability to concentrate, or despair. Learning then becomes impossible for them (Kogelman, Nigro, & Warren, 1978). Because these students do not achieve success in mathematics, they tend to develop negative attitudes towards it, attitudes which are likely to adversely influence future performance.

In the past, fear, dislike or avoidance of mathematics may have limited students' educational and occupational choices; nevertheless, what is generally known as "mathematics anxiety" has not prevented them from entering university liberal arts curricula and training for professional positions as historians, linguists, or social scientists. Today, however, educators recognize mathematics anxiety as a significant problem because of the increasing importance of mathematics in disciplines which have only recently begun to require quantitative skills of their practitioners. It is not as easy as it once was for students to attain professional status without having first achieved success in mathematics.

Anxiety reduces achievement in mathematics learning and is likely, therefore, to prevent some students from achieving success even in liberal arts, business, and humanities curricula. If a more thorough understanding of mathematics anxiety and of the interrelationships between it and other variables can be accomplished, theories might be established concerning constructs such as mathematics anxiety. Such theories are necessary as a prior step to the development of treatments designed to help students to overcome or alleviate problems in this area.

Previous researchers have measured mathematics anxiety using a number of different scales, yet they have failed to establish the construct validity of the instruments used. Construct validity is the degree to which the test scores can be accounted for by certain explanatory constructs. Constructs are normally considered as unob-

servable phenomena that help to explain an individual's behavior (Mehrens & Lehmann, 1969). In addition, previous researchers have tended to characterize mathematics anxiety as a unidimensional construct and have not considered its possible multidimensional nature. Research in the area of mathematics anxiety has also been concerned with determining the relationship between attitudes towards mathematics and certain other variables, namely: achievement, sex, socioeconomic status (SES) and personality characteristics, such as self-confidence and aggressiveness.

Interviews conducted by the author suggested that mathematics anxiety may also be related to "dogmatism" (Rokeach, 1960), a relationship not previously investigated. Previous research has, however, suggested that there is a strong relationship between anxiety and dogmatism (Fruchter, Rokeach, and Novak, 1958). During the author's interview with students, it appeared that students who dislike mathematics dislike or fear the challenge of being asked to obtain solutions (usually numerical) to specific problems. The possibility of failing to solve a problem was very threatening to these students; they were anxious about the possible embarrassment due to their poor performance. They also showed a tendency to approach mathematical problems dogmatically, clinging to rules or cut-and-dried procedures and preferring to cite these as the basis for solving problems rather than trying to internalize an understanding of the solutions.

It appears then that a student's difficulty with mathematics may be independent of ability; mathematics anxiety may be a question of

attitude rather than aptitude. Sheila Tobias (1978b) characterizes a student's verbalization of mathematics anxiety in the following way:

"I hate math. I can't get any facts from my figures. In grammar school I liked mathematics, but one day I got a problem I couldn't solve. I felt like sudden death."

Tobias's book (1978b) gives an analysis of the problem and the beginning of a cure. She states to such students:

"You are not dumb; you have just been intimidated by poor schooling, murky texts, and mythologies about mathematical minds. Now is the time for you to understand where your fear of mathematics came from and how you can conquer it."

In view of the foregoing discussion, there is a need for greater understanding of the interrelationships among variables reflecting attitudes toward mathematics. Only after such understanding can theories be established concerning constructs such as mathematics anxiety. Such theories are necessary as a prior step to development of treatments designed to overcome or alleviate student problems in this area.

The purpose of this study was to investigate the extent to which distinct attitudes toward mathematics can be viewed as reflection of a variety of personal characteristics as opposed to manifestation of a single underlying attitude about mathematics. More specifically it sought to establish the validity of the construct, mathematics anxiety, and the scales used to measure it; to investigate the possibility that mathematics anxiety may be a multidimensional construct, and to determine the strength of the relationship between factors describing mathematics anxiety and other variables, including dogmatism.

Overview of Procedures

A series of self-reporting questionnaires and survey instruments was administered in several freshman college mathematics classes at

several different times to prevent cross-instrument contamination.

The questionnaires provided scores reflecting constructs such as:

- (1) Defensiveness
- (2) Self-confidence
- (3) Aggressiveness
- (4) Dogmatism
- (5) Test anxiety
- (6) "Mathematics anxiety" scale (as measured by unidimensional scale bearing this title)
- (7) Other mathematics attitudes and personal characteristics.

These scores were then factor analyzed and subjected to other statistical procedures to establish their interrelationships. From these results, hypotheses about the nature and treatment of psychological problems concerning mathematics anxiety were made.

Instrumentation

Eight instruments were used in this study. The first two listed below yielded data about personality. The third was a score reflecting general test anxiety. The other five as a group measured the students' attitudes toward mathematics. The eight instruments were:

1. The Adjective Check List (Gough, 1952): The Adjective Check List (ACL) consists of 300 adjectives describing human behaviors and attitudes. Responses yield scores on 24 scales, 21 of which were used for the study.
2. Short-Form Dogmatism Scale (Troidahl & Powell, 1965): This scale is designed to measure individual dif-

ferences with respect to a complex of interrelated characteristics such as deference to authority, resistance to change and degree of fatalism.

3. Test Anxiety Inventory (Spielberger, 1978): This scale consists of 20 items pertaining to feelings and reactions while taking tests.

Fennema-Sherman Mathematics Attitudes Scales (1976) consist of a group of five instruments as follows:

4. Mathematics Anxiety Scale: This scale is intended to measure feelings of anxiety, dread, and nervousness.
5. Attitude Toward Success in Mathematics Scales: This scale is designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics.
6. Effectance Motivation in Mathematics Scale: This scale involves attitudes related to problem solving in mathematics. It measures effectance as applied to mathematics. The dimension ranges from lack of involvement in mathematics to active enjoyment and seeking of challenge.
7. Usefulness of Mathematics Scale: This scale is designed to measure a student's beliefs about the usefulness of mathematics.
8. Confidence in Learning Mathematics Scale: This scale is intended to measure confidence in

one's ability to learn and to perform well in mathematical tasks.

In addition, the following personal data about students were collected: sex, socio-economic status (SES), curriculum, high school mathematics background, college grade point level, and mathematics achievement as indicated by final grades in the courses the students were taking.

Subjects

The subjects of the study were 491 freshman students enrolled in College Algebra, College Trigonometry, Calculus, Mathematics as a Liberal Art, and Calculus and Matrices courses at Virginia Polytechnic Institute and State University during the 1980-81 academic year. These students were enrolled primarily in liberal arts curricula but a few students were from professional disciplines such as engineering, business, architecture and the physical and natural sciences programs.

Assignment of the students to the classes was not influenced by any variable known to be related to the scales of the study. The students did not know who their instructors would be at the time of registration, and the instructors did not interact with the measurement process to any great extent.

Administration of Instruments

The subjects were in 17 classes of about 30 students each. On various days throughout the academic quarter, one of the instruments

described previously was administered. The purpose of this timing was the prevention of "overflow" from one instrument to another. This problem had become evident in an earlier pilot study in which two of the scales of the study were administered simultaneously and were found to intercorrelate much more highly than reported in the literature.

Factor Analysis

Data for this study were examined by using factor analytic techniques. Factor analysis is a type of multivariate analysis which "isolates a series of underlying 'dimensions' of individual differences, and makes it possible to describe a large set of test scores in terms of a relatively small number of such dimensions" (Carroll, 1966). Factor analytic techniques can also help researchers gain a better understanding of the complex and poorly defined interrelationships among a large number of imprecisely measured variables.

For this study, twenty-eight variables were entered into the factor analysis: five scores on the tests measuring attitudes towards mathematics; the score on the Test Anxiety Inventory; twenty-one scores from the Adjective Check List, and the dogmatism score. A matrix of intercorrelations among the twenty-eight variables was computed and subjected to a principal component extraction of roots. After the dimensions underlying the 28 variables were identified, their relationship to personal variables was determined.

Chapter 2

LITERATURE REVIEW

Previous research in the area of mathematics anxiety has been primarily concerned with investigating the relationship between mathematics achievement and attitudes towards mathematics, determining the possible causes of mathematics anxiety, and examining the relationship between attitudes towards mathematics and sex differences. A significant weakness in most of the research to date has been its failure to establish the validity of the construct; that is, previous research has assumed the existence of mathematics anxiety without giving prior attention to determining its nature. Most previous research has considered mathematics anxiety as a unidimensional construct and limited it to looking at differences in means on scores from a single attitude type survey.

Two important aspects of a student's learning mathematics are attitude and achievement. Neale (1969) stated that something called "attitude" plays an important role in learning mathematics. According to Scandura (1967), a positive attitude toward mathematics is an important factor in causing students to learn mathematics. Mager (1968), Neale (1969), and Anttonen (1969) had similar conclusions about attitude toward mathematics.

A variety of studies have suggested that high anxiety, or a negative attitude toward mathematics, is associated with low scores on

arithmetic achievement tests (Feldhusen, 1965; McCandless and Castaneda, 1956; and Philips, 1962). In another study, Biggs (1965) revealed that anxiety restrained one's ability to learn mathematics and that anxiety appears to be more easily aroused in learning mathematics than it is in other subjects.

Dreger and Aiken (1958), the authors of a well-known scale of mathematics attitude, determined that first-year college students have emotional reactions that can be called "number anxiety". Additionally, it appears from this work that persons with high number anxiety tend to make lower grades in mathematics. This research suggests that negative attitudes towards mathematics, referred to as mathematics anxiety or mathphobia, interacts with mathematics achievement. The causes of this phenomenon, however, appear to be complicated and related to early experience in mathematics, parental attitudes, and sex differences.

Research conducted in the Mathematics Anxiety Program at the University of Minnesota (Hendel, 1977) suggests that there are several factors which interact to produce the phenomenon of mathematics anxiety. The most common of these is past experiences with mathematics education. Most frequently these events involved negative experiences with mathematics teachers, where teachers embarrassed students or ignored the difficulties students were having (Mathison, 1977).

According to Poffenberger and Norton (1959), parents may also affect the child's attitude and performance by their expectations of child's achievement, by their encouragement, and by their own attitudes.

As evidence for their hypothesis that the conditioning of children's attitudes occurs in the family, the authors cite the results of a study of 390 University of California freshmen. The students filled out a questionnaire concerning their own attitudes and the attitudes and expectations of their parents.

The findings were that the students' attitudes toward mathematics were positively related to how they rated their fathers' attitudes toward mathematics. The attitudes of the students were also related to their reports of the level of achievement in mathematics which their fathers and mothers expected of them.

Poffenberger and Norton suggested that attitudes reported for the mothers were not significantly related to students' own attitudes because only a small number of students indicated that their mothers liked mathematics.

Many earlier studies of mathematics attitudes investigate the relationship between attitude and sex differences. Aiken is one of the leaders in investigating attitude toward mathematics and many of his studies involve sex difference. Aiken and Dreger (1961) found that attitude toward mathematics significantly improved the prediction of achievement in mathematics for females, but not for males, when achievement was based on final course grades.

In a study of college freshmen, Aiken (1971) found that the mean mathematics attitude score of boys was higher than that of girls. In a later study (Aiken, 1972), Aiken found that the number of high school students who had greater interest in mathematics seemed to decline as students progressed to college.

Aiken's (1970) survey of the literature lists four studies that showed a positive correlation between attitude towards mathematics and sex (males do better). He also reported on five studies that showed a positive correlation between achievement in mathematics and sex. In an updated literature review, Aiken (1976) summarizes four studies that showed no relationship between attitude towards mathematics and sex. He also describes nine studies that showed a positive correlation between attitudes toward mathematics and sex (males do better) and noted that each of these studies concerned a population above the junior high school level.

In the past, many researchers have concluded that male superiority in mathematics achievement is almost always found (Glennon and Callahan, 1968); but many are currently suggesting that sex-related differences in mathematics are age related (Callahan & Glennon, 1975; Fennema, 1974, 1977; Hilton & Berglund, 1974; MacCoby & Jacklin, 1974; Suydam & Weaver, 1975).

The National Longitudinal Study of Mathematical Abilities (NLSMA) and the National Assessment of Educational Progress (NAEP) do report sex-related differences in favor of males (Wilson, 1972). Inspection of their data indicates that these differences increase as learners progress from grade 6 to grade 12.

Lucy Sells (1976) reported that of a systematic random sample of freshmen admitted to the University of California at Berkeley, 57 percent of the males had three and one-half or more years of high school mathematics required for freshmen calculus while only 8 percent of the females had this requirement.

This fact that females opt less for mathematics courses in high school is brought out in a study by Fennema and Sherman (Winter, 1977). Their study of 2,919 girls and 3,347 boys enrolled in mathematics classes in four public high schools found that not only were there more boys enrolled overall, but more boys studied mathematics for a total of four years in high school.

Observation of students at the college level, including the distribution of males and females in advanced mathematics courses and the separation of sex by choice of major field, have supported the researchers' (Aiken, 1971; Fennema & Sherman, 1977; Tobias, 1978a) opinion that mathematics and science-related fields are a male's domain. These observations have also supported Lucy Sells' identification of mathematics as the "critical filter" to career choices.

The conclusion reached by Fennema and Sherman (1976), after two years of study of sex-related differences in mathematics achievement of students in grade 6 to 12, is that when relevant factors are controlled, sex-related differences in favor of males do not appear often, and when they do they are not large.

Fennema and Sherman (1977) later investigated (1) mathematics achievement (Test of Academic Progress) of 589 female and 644 male predominantly white, 9-12 grade students enrolled in mathematics courses from four public high schools in a large Wisconsin city, (2) relationships to mathematics achievement and to sex-related differences in mathematics achievement of 3 cognitive variables and 8

affective variables. Complex results were obtained. The results showed important relationships between socio-cultural factors and sex-related cognitive differences.

The investigators administered four of the five Fennema-Sherman Mathematics Attitudes Scales and found relatively low intercorrelations among them. They concluded that each scale measures a different construct.

While Fennema and Sherman were primarily interested in measuring sex related differences in mathematics attitude and achievement, their study is noteworthy for its methodology. It was designed to consider mathematics anxiety as possibly a multidimensional phenomenon and it used factor analytic techniques to do so. Four factors emerged from the analysis. Factor A is made up of Confidence in Learning Mathematics. Factor B is made of Mother, Father, and Usefulness of Mathematics Factor C is an Attitude Toward Success Factor Attitude Toward Success appeared for Males in Factor D.

The Fennema-Sherman study is innovative in suggesting that mathematics anxiety may be a multidimensional construct. Its weakness, however, is its focus on sex differences. In view of this and the previous research in the area, there is clearly a need for the kind of investigation reported in this study. Not only is the possibly multidimensional nature of mathematics anxiety considered, but its validity as a construct is examined, as scores on a large number of variables are analyzed and their relationship to some important personal characteristics is investigated.

Chapter 3

PROCEDURES

Instrumentation

After studying the merits of a number of available instruments, the Adjective Check List, Short-Form Dogmatism Scale, Test Anxiety Inventory, and the Attitudes Toward Mathematics Scales were selected as being most appropriate. They are relevant to the objectives of this study and meet minimum validity and reliability requirements. These instruments are presented in the appendix. A short description of each is given below.

The Adjective Check List (Gough, 1952)

The ACL consists of 300 adjectives describing human behaviors and attitudes. Examinees are instructed to select from the list those adjectives which they perceive as describing themselves.

Validity: Observational data presented in the test ACL manual (Gough and Heilbrum, 1965) suggest that individuals scoring in the high or low range of the scales tend to be described by others in terms of the adjectives characterizing the extremes of the scales.

Reliability: The test-retest reliability coefficients presented in the test manual vary considerably. Some scales appear to remain reasonably stable over time while others show

marked instability. Test-retest reliability coefficients were found to vary from a low of $+0.01$ to a high of $+0.86$, with a mean of $+0.54$. Because of the reported variation in the reliability of the scales, reliabilities of these scales were determined by a sample of students similar to the sample under study and the mathematics study group to administering the ACL; these coefficients are presented in Table 2 (page 28). A list of the 21 scales of the ACL used in this study is given as follows:

- (1) Defensiveness. The higher-scoring person is apt to be self-controlled and resolute in both attitude and behavior, and insistent and even stubborn in seeking his objectives. The lower-scoring person tends to be anxious and apprehensive, critical of himself and others, and given to complaints about his circumstances.
- (2) Unfavorable adjectives. The high-scoring subject strikes others as rebellious, arrogant, careless, and cynical.
- (3) Self-confidence. The high-scorer is assertive, affiliative, out-going, persistent, an actionist. He wants to get things done and is impatient with people or things standing in his way. The low-scoring person is a much less effective person in the everyday sense of the word.
- (4) Self-control. High scorers tend to be serious, sober individuals, interested in and responsive to their obligations. They are seen as diligent, practical and loyal workers. At the low end of the scale, one seems to find the inad-

quately socialized person, headstrong, complaining, disorderly and impulsive.

- (5) Lability. The high-scoring subject is seen favorably as spontaneous, but unfavorably as excitable, restless, and nervous. He seems impelled toward change and new experience. The low-scorer is more routinized, planful and conventional.
- (6) Personal adjustment. The high-scoring subject is seen as dependable, peaceable, trusting, friendly, loyal, and wholesome. He seems to possess the capacity to "love and work".
- (7) Achievement. The high-scoring subject is usually seen as intelligent and hard-working. The low-scoring subject is more skeptical, more dubious about the rewards.
- (8) Dominance. The high-scorer is confident of his ability to do what he wishes and is direct and forthright in his behavior. The low scorer is unsure of himself, and avoids situations calling for choice and decision-making.
- (9) Endurance. The high subject is typically self-controlled and responsible, but also idealistic and concerned about truth and justice. The low-score is erratic and impatient.
- (10) Order. High-scorers are usually sincere and dependable, but at the cost of individuality and spontaneity. Low-scorers are quicker in temperament and reaction and might be called impulsive.

- (11) Intracception. The high-scorer is reflective and serious; he is also capable, conscientious, and knowledgeable. The low-scorer is aggressive in manner, and quickly becomes bored or impatient with any situation. He is a doer, not a thinker.
- (12) Nurturance. The subject high on this scale is of a helpful and nurturant disposition. The subject scoring low on this scale is the opposite of the high scorer. He is skeptical, clever and acute.
- (13) Affiliation. The high-scorer is ambitious. The low-scorer is more individualistic and strong-willed.
- (14) Heterosexuality. The high-scorer is interested in the opposite sex as he is interested in life, experience, and most things around him.
- (15) Exhibition. Persons who are high on this scale tend to be self-centered and even narcissistic. Persons who score low tend toward apathy, self-doubt, and under inhibition of impulse.
- (16) Autonomy. The high-scorer is independent and autonomous. The low-scorer is of a moderate and even subdued disposition.
- (17) Aggression. The subject high on this scale is both competitive and aggressive. The subject low on this scale is much more of a conformist.
- (18) Change. Persons high on this scale are typically perceptive, alert and spontaneous individuals. The low-scorer seeks

stability and continuity in his environment.

- (19) Succorance. The high-scorer is dependent on others, seeks support, and expects to find it. On the contrary, the low-scorer is independent, resourceful, and self-sufficient.
- (20) Abasement. High-scorers are not only submissive and self-effacing, but also appear to have problems of self-acceptance. The low-scorer is optimistic, poised, productive, and decisive.
- (21) Deference. The high-scorer is typically conscientious, dependable, and persevering. The low-scorer is more energetic, spontaneous, and independent; he likes attention, likes to supervise and direct others, and to express his will.

Short-Form Dogmatism Scale (Troidahl and Powell, 1965)

In this study the 20 item Short-Form Dogmatism scale was used to measure students' resistance to change. This scale was selected over the long form (Rokeach, 1956) because it does not take as long to administer and would be preferable for administration in the classes under study. It was also felt that the Short-Form Dogmatism Scale should be used because of its high correlation (above .90) with the long-form scale. Responses are obtained on a four-point Likert scale: 1 = Agree, 2 = Tend to agree, 3 = Tend to disagree, and 4 = Disagree.

Test Anxiety Inventory (TAI, Spielberger, 1978)

The TAI consists of 20 statements which measure the feelings and reactions students exhibit while taking tests. Responses are obtained on a four-point Likert scale as described above. Scoring weights are assigned to the item responses chosen and total scores range from a minimum of 20 to a maximum of 80.

Validity: In order to determine the validity of the TAI, it has been correlated with the WEQ-Emotionality scale (Liebert and Morris, 1967), a scale which measures similar reactions, and correlations as high as .71 have been found.

Reliability: The test-retest reliability coefficient was found to be .80.

Fennema-Sherman Mathematics Attitudes Scales

These instruments are designed to measure Attitudes Toward the Learning of Mathematics (1976). Among them five scales were selected to assess the mathematics attitudes of freshmen students in College Algebra, College Trigonometry, Calculus, Mathematics as a Liberal Art, and Calculus and Matrices. They are:

- (1) Mathematics Anxiety Scale,
- (2) Attitude Toward Success in Mathematics Scale,
- (3) Effectance Motivation in Mathematics Scale (extent to which mathematics is viewed as enjoyable),
- (4) Usefulness of Mathematics Scale,
- (5) Confidence in Learning Mathematics Scale.

The Fennema-Sherman mathematics attitude scales are designed for administration to high school students. For this study several items were revised so that they would be appropriate for college students.

Item responses for the five tests are obtained on a four-point Likert scale as described before. Each test consists of 12 items. Half of the 12 items of each test are positively worded while the other half are negatively worded. Split-Half reliability for the five tests is given by the authors as follows:

(1) Mathematics Anxiety Scale	.89	✓
(2) Attitude Toward Success in Mathematics	.87	
(3) Effectance Motivation in Mathematics Scale	.87	
(4) Usefulness of Mathematics Scale	.88	
(5) Confidence in Learning Mathematics Scale	.93	

Subjects

Approximately 500 students in freshman mathematics courses at Virginia Polytechnic Institute and State University during the 1980-81 academic year were the subjects of this study. The students were enrolled in College Algebra and Trigonometry, Calculus for the Biological Sciences, Calculus and Matrices, and Mathematics as a Liberal Art. Students enrolled in a total of 17 classes were surveyed; most of them were liberal arts majors. Table 1 shows the distribution of the subjects by area of study, sex, SES, high school mathematics background, college academic level, and the achievement of that course.

Table 1
 Numbers of Subjects in Various Personal Data Categories
 (N=491)

		Number
Course	College Algebra	73
	College Trigonometry	172
	Calculus	62
	Math as a Liberal Art	50
	Calculus and Matrices	134
Sex	Male	175
	Female	232
	Unspecified	84
Socio-economic status (SES)	Profession/Managerial	269
	White Collar/Skilled Trade	104
	Nonskilled	29
	Unspecified	89
Quantitative Requirement of Major (QROM)	High (Math, Physical Science, Engineering)	15
	Medium (Biology, Biochemistry, Agriculture, Architecture)	101
	Low (Arts, Social Science, Education, Business, Home Economics)	282
	Unspecified	93
Highest High School Math	Algebra I	5
	Geometry	22
	Algebra II	116
	Trigonometry	113
	Probability	7
	Advanced Math	108
	Calculus	35
	Unspecified	85
Grade Point Level (QCA)	Hardly Ever Below B	72
	Mostly B's and C's	183
	Mostly C's	97
	C's and D's or lower	35
	Entering Freshmen (no grade yet)	21
	Unspecified	83
Course Grade	A	89
	B	121
	C	119
	D	70
	F	47
	Unspecified	45

This sample was selected because it was felt to represent adequately the population under consideration: average undergraduate students not pursuing degrees in curricula requiring a predominance of mathematics courses. Virginia Polytechnic Institute and State University is a large land grant university which requires at least one year of mathematics for all undergraduates. Its admission policies are moderately selective, and its student body may be considered to be similar to that of most large state-supported universities.

Administration of Instruments

The instruments were administered on various days throughout the academic quarter. In order to prevent cross-instrument contamination, each scale was administered at least two days apart.

Students were administered the eight instruments in the following order:

- (1) Usefulness of Mathematics Scale
- (2) Test Anxiety Inventory
- (3) Mathematics Anxiety Scale
- (4) Adjective Check List
- (5) Short-Form Dogmatism Scale
- (6) Attitude Toward Success in Mathematics Scale
- (7) Effectance Motivation in Mathematics Scale
- (8) Confidence in Learning Mathematics Scale and Personal Data

The Fennema-Sherman scales were not administered in their original version. The order of items was changed to provide for a random interspersion of positively worded and negatively worded items, and, in some cases, the items were revised to use more adult language.

In addition to scores on these scales, six personal variables for each student were collected: sex, major, high school mathematics background, SES, self-reported grade point average. As a measure of mathematics achievement, the final grades in the courses the students were taking were included in the data set.

Data Analysis

The data for this study were analyzed by using factor analytic procedures. Scores for the 491 freshman students on all eight tests including their personal data were entered into the factor analysis. A matrix of intercorrelations among the variables was computed and subjected to a principal component extraction of roots. The resulting factor matrix was rotated using the varimax procedure to determine the variables related to mathematics anxiety. Factor scores reflecting these variables were then correlated with variables arising from the personal data questionnaires. Figure 1 shows the general research design. Eight instruments (28 variables) and six personal data (6 variables) were used in this study. There are altogether 34 variables. The eight instruments contain 2 groups of factors. The first group contains Personality Factors, including Dogmatism and Adjective Check List (21 ACL scales used). The second group contains Mathematics

Attitude Factors, including Confidence, Motivation, Success, Mathematics Anxiety Scale, Test Anxiety, and Usefulness in Mathematics.

The six personal factors are: Sex, SES, Curriculum Major, High School mathematics background, College grade point level and Final grade.

Figure 1 indicates the factors relating to Mathematics Anxiety.

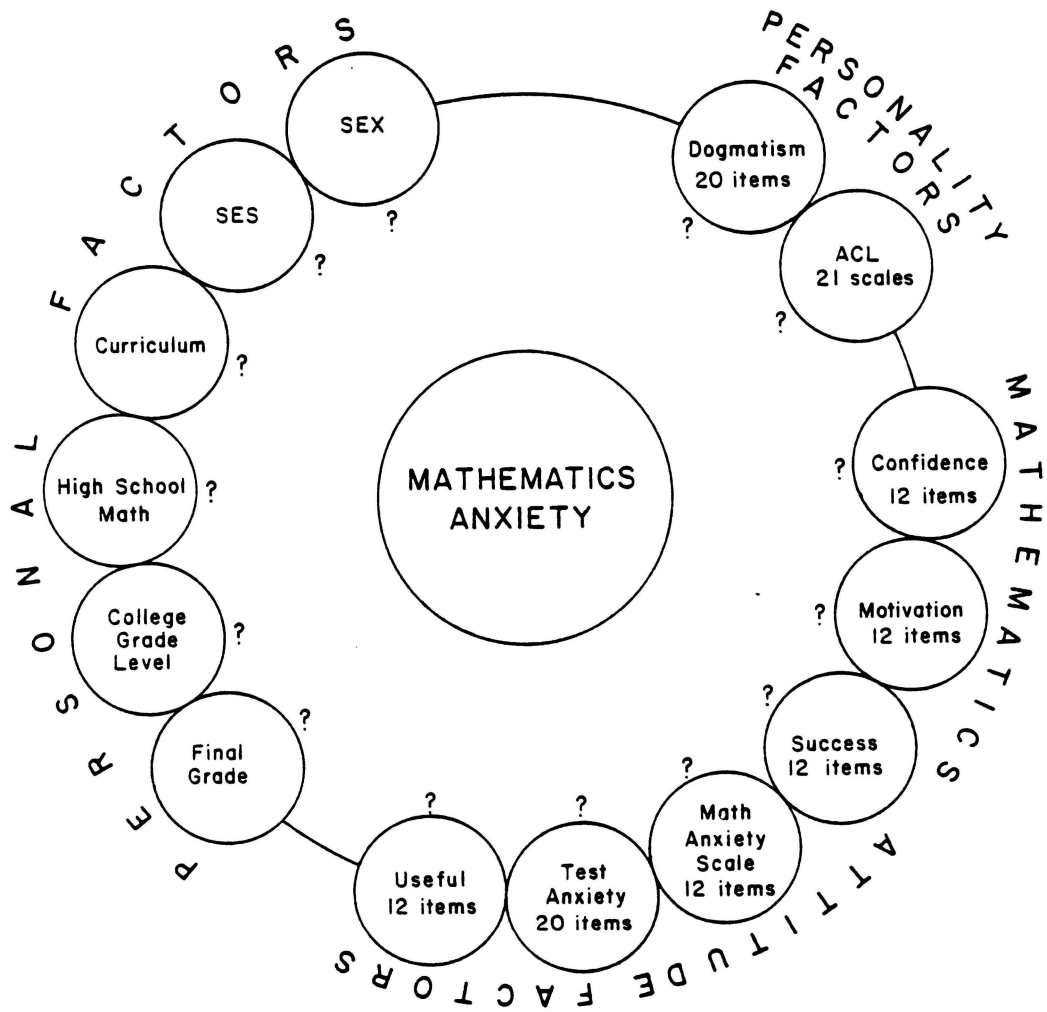


Figure 1. General Research Design

Chapter 4

FINDINGS, DISCUSSIONS, SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The primary objective of this study was to investigate the possible multidimensional nature of mathematics anxiety, a construct traditionally characterized as a unidimensional phenomenon. The study was also designed to establish the validity of the construct, mathematics anxiety and of the scales used to measure it; and to describe the interrelationship among variables possibly influencing the degree to which individual students experience mathematics anxiety.

The investigator administered a variety of instruments to a sample of 491 freshman students enrolled in College Algebra, College Trigonometry, Calculus, Mathematics as a Liberal Art, and Calculus and Matrices. Scores from 28 scales and six personal data questionnaires were used as the basis for the analysis. The data were processed using several existing computer programs including PROC FACTOR of the Statistical Analysis System (SAS Institute, 1976) and the Comprehensive Questionnaire Analysis Program (Frary, 1974).

Table 2 presents reliability estimates for the 28 scales used. The reliability estimates (coefficient alpha) for the mathematics attitude, test anxiety and dogmatism scales are those determined for the sample under study; information from other sources indicated their high reliability, a finding confirmed by these results. It was not

Table 2
Reliability Estimates

Scale	Coefficient Alpha	No. of Items
Math Attitude Scales		
Usefulness	.94	12
Effectance	.92	12
"Math Anxiety"	.95	12
Confidence	.95	12
Success	.85	12
Adjectives Check List*		
Unfavorable Adjectives	.89	75
Defensiveness	.88M, 87F	28M, 36F
Self-Confidence	.74	40
Self-Control	.72	44
Lability	.53	47
Personal Adjustment	.77	36
Achievement	.83	38
Dominance	.82	55
Endurance	.80	47
Order	.80	41
Intracception	.82	30
Nurturance	.88	64
Affiliation	.90	34
Heterosexuality	.75	29
Exhibition	.74	47
Autonomy	.66	44
Aggression	.82	69
Change	.55	33
Deference	.72	47
Succorance	.59	20
Abasement	.70	47
Test Anxiety	.94	20
Dogmatism	.82	20

F - Female

M - Male

* The Coefficient Alpha of the 21 scales of ACL is given by
Giles (1981).

feasible, however, to compute coefficient alpha for the Adjective Check List (ACL) scale responses from subjects of this study, and reliability coefficients reported in the manual for the Adjective Check List (Gough & Heilbrum, 1965), ranged from very high (.86) to very low (.01) by test and retest. Therefore the coefficient alpha estimates were obtained for a sample of nearly 1,200 students by Giles (1981) and the mathematics group (491) now under study, or a total sample of approximately 1,700 students are from Virginia Polytechnic Institute and State University. The sample of 1,200 students took the ACL as a part of their student-teaching requirements (Giles, 1981). The relatively high alpha coefficients for these twenty-eight variables indicate satisfactory levels of reliability; scores from the mathematics attitudes and the test anxiety scales, however, were found to be somewhat more reliable than those from the ACL variables alone.

Tables 3 and 4 present sample size, means, and standard deviations for all 34 variables. Table 3 lists this information for the 28 attitude/personality items; Table 4 includes the six personal data items. The sample size for items varies because not all students attended class each day that an inventory was administered.

Scores for the mathematics attitude scales could range from a low of 12 to a high of 48, the lower score indicating a more positive attitude. Their means and standard deviations are shown in Table 3. These statistics show that scores based on the success item were lower and varied somewhat less than scores from any of the other mathematics attitude scores.

Table 3

Ns, Means, Standard Deviations of Math Attitude Scales
and Personality Variables

Variable	N	Mean	Standard Deviation
Math Attitude Scales			
Usefulness	414	23.61	8.58
Effectance	374	31.00	8.18
"Math Anxiety"	387	28.40	9.27
Confidence	449	27.98	9.53
Success	389	19.36	5.59
Adjective Check List			
Unfavorable Adjectives	394	50.41	10.07
Defensiveness	394	46.76	10.07
Self-Confidence	394	48.76	9.49
Self-Control	394	46.22	8.80
Lability	394	51.51	9.76
Personal Adjustment	394	46.70	10.00
Achievement	394	48.13	9.68
Dominance	394	50.36	9.76
Endurance	394	47.97	9.37
Order	394	46.78	9.31
Intraception	394	47.50	10.16
Nurturance	394	48.00	10.61
Affiliation	394	47.25	10.34
Heterosexuality	394	52.16	11.34
Exhibition	394	52.04	9.29
Autonomy	394	52.55	9.55
Aggression	394	52.38	9.21
Change	394	50.79	10.00
Deference	394	45.69	9.96
Succorance	394	47.21	8.96
Abasement	394	46.71	9.71
Text Anxiety	410	49.26	12.99
Dogmatism	388	57.24	8.48

Raw scores for the twenty-one ACL items were standardized, with a mean of 50 and standard deviation of 10. This standardization was based on national norming data provided by the publisher of the ACL. Low standard scores indicate that students would tend not to describe themselves as possessing these characteristics. High scores, on the other hand, indicate that students would tend to use these adjectives to describe themselves. The means for the mathematics group on the 21 scales of the ACL ranged between 45.69 to 52.55, with standard deviations of approximately 8.8 to 11.3. Most means are very close to 50 and all standard deviations are very close to 10.

The coding for the socio-economic status (SES) or parents' occupation is as follows:

- 1 = Professional/managerial
- 2 = White collar/skilled trade
- 3 = Nonskilled

The mean of the SES of this sample is 1.42. The results presented in Table 4 show that most parents of students in this sample are well-educated and have substantial job training.

In order to code majors for ease of data analysis, the majors were categorized into three levels according to the amount of mathematics required to complete their curricula: high (score 1) for majors in the physical sciences, engineering, mathematics, computer science and statistics; medium (score 2) for biology, biochemistry

and architecture; low (score 3) for liberal arts, social science, education, business and home economics. The mean levels or Quantitative Requirement of the Major (QROM) is 2.43, which indicates that most students were in majors requiring low to moderate numbers of quantitative courses.

The coding for high school mathematics background (HSMath) is:

- 1 = Algebra I
- 2 = Geometry
- 3 = Algebra II
- 4 = Trigonometry
- 5 = Probability
- 6 = Advanced mathematics
- 7 = Calculus

The mean of the highest mathematics course taken in high school is 4.38 as shown in Table 4. This indicates that a majority of the students in the sample had not gone beyond trigonometry in high school.

There were more females (232) than males (175) in this sample. The coding for sex is: 1 = Male and 2 = Female.

The coding for students college grades (QCA) is:

- 1 = Hardly ever below B
- 2 = Mostly B's and C's
- 3 = Mostly C's
- 4 = C's and D's or lower
- 5 = Entering freshman (no grades yet)

The majority of students indicated that their grades were mostly B's and C's and mostly C's, an average of 2.4 on the scale used in this study.

The coding for course grades is:

F = 0

D = 1

C = 2

B = 3

A = 4

The mean for mathematics courses is 2.29.

After these descriptive statistics were obtained, factor analysis was used to order and simplify the reporting of correlations among the 28 variables and to reduce the variables to a small number of factors, some of which could be considered the dimensions possibly influencing the degree to which students experience mathematics anxiety. A matrix of intercorrelations among the mathematics attitude scales and the personality variables is presented in Appendix A. The highest correlations in the matrix suggest some interesting information. The highest correlation of .82 is between mathematics confidence and mathematics anxiety. The fact that this correlation is positive is a result of the direction in which the responses were scaled: it does not indicate that students who experience high mathematics anxiety will

Table 4

Ns, Means, Standard Deviations of Six Personal Data

Personal Data	N	Mean	Standard Deviation
1. Socio-economic Status	410	1.42	.65
2. Quantitative Requirement of Major	393	2.43	.73
3. High School Math	413	4.38	1.54
4. Sex	415	1.58	.50
5. Quality Credit Average	415	2.40	1.04
6. Course Grade	453	2.29	1.26

also be confident; rather it indicated the reverse. As would be expected, students lacking confidence in mathematics tend to experience high mathematics anxiety. Effectance, that is, enjoyment of mathematics and motivation to learn, was also found to be related to mathematics confidence as was students' attitude toward the usefulness of mathematics. It appears, then, that if students enjoy mathematics, and if they believe in its utility, they will be more confident. Mathematics anxiety was found to be correlated negatively with course grade: students not doing well in mathematics understandably suffer greater anxiety than those earning higher grades.

This intercorrelation matrix was subjected to a principal component extraction of roots. Six eigenvalues greater than unity were found. Figure 2 shows the graph of eigenvalues for the six factors. The six factors were subjected to varimax rotation, the results of which are presented in Table 5. Tables 6 through 11 present the factor loadings and communality (h^2) for each of the six factors. Interpretation of each factor, labeled to represent the variables which loaded most highly on it, follows.

Factor One, shown in Table 6, accounts for 27.69 percent of the common variance in the matrix of 28 variables, was a Personal Effectiveness Factor. Variables loading most heavily on this factor, which includes 13 of the 21 ACL scales, are defensiveness, self-control, affiliation, personal adjustment, nurturance and intraception. Unfavorable adjectives, aggression and autonomy loaded negatively on Factor One. The favorable scales with higher loadings of this factor

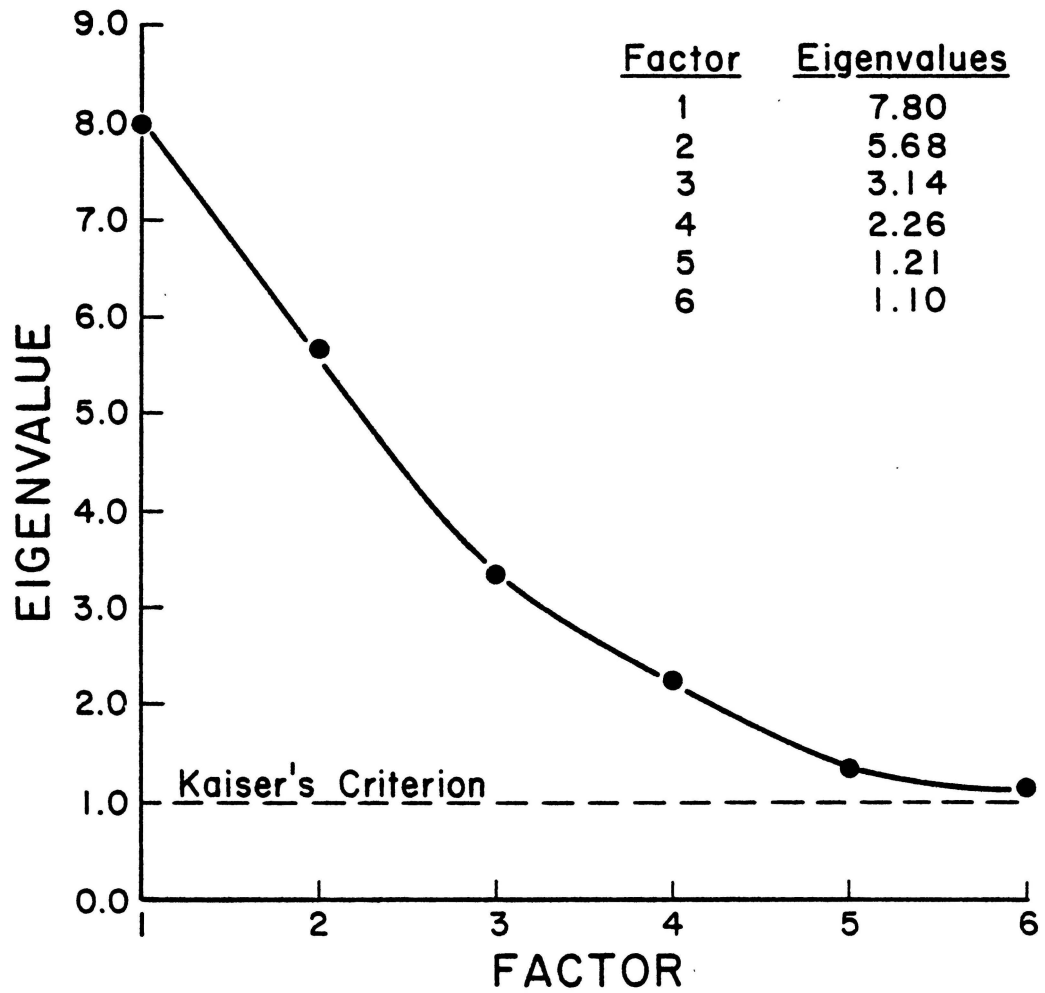


Figure 2. Graph of Eigenvalues for Six Factors

Table 5

Varimax Rotated Factor Matrix of 28 Variables
for 6 Factor Loadings

Scale Number	Variables	Factor 1 Personal Effectiveness	Factor 2 Assertive- ness	Factor 3 Math Anxiety	Factor 4 Outgoing- ness	Factor 5 Success	Factor 6 Dogmatism	h^2
1.	Usefulness	-.03	.05	.69*	.03	-.19	-.09	.52
2.	Test Anxiety	.03	-.16	.53*	.04	.37	.46*	.66
3.	Math Anxiety	-.08	-.10	.89*	-.03	.12	.09	.84
4.	Unfavorable	-.71*	-.08	.01	.09	.10	.11	.55
5.	Defensiveness	.87*	.21	-.06	.07	.02	.11	.82
6.	Self-confidence	.11	.85*	.01	.16	.12	-.02	.77
7.	Self-control	.80*	-.17	-.04	-.32	.00	.03	.77
8.	Lability	-.00	.07	.03	.79*	-.13	.01	.65
9.	Personal Adj.	.86*	.08	-.05	.07	.00	-.05	.75
10.	Achievement	.53*	.70*	-.18	-.09	.09	.10	.82
11.	Dominance	.32	.89*	-.13	.03	.06	.07	.92
12.	Endurance	.72*	.36	-.11	-.44*	.06	.06	.86
13.	Order	.68*	.26	-.12	-.47*	.06	.05	.77
14.	Intracception	.81*	-.00	-.07	.13	-.12	-.06	.69
15.	Nurturance	.87*	-.15	.02	.27	.05	.05	.86
16.	Affiliation	.79*	.11	-.05	.45*	.08	.08	.85
17.	Heterosexuality	.37	.22	-.02	.64*	.21	.05	.63
18.	Exhibition	-.26	.68*	-.06	.41*	.19	.00	.74
19.	Autonomy	-.55*	.65*	.00	.25	-.07	-.13	.81
20.	Aggression	-.79*	.47*	-.01	-.04	.14	.01	.87
21.	Change	-.05	.31	.05	.75*	-.01	-.13	.68
22.	Succorance	-.31	-.63*	-.03	-.02	.37	.16	.65
23.	Deference	.59*	-.68*	-.02	-.20	.09	.10	.87
24.	Abasement	.12	-.88*	.07	-.07	.14	.06	.82
25.	Dogmatism	-.00	.04	.05	.07	.21	.88*	.83
26.	Success	.04	-.02	.11	.03	-.77*	.17	.63
27.	Effectance	-.03	-.06	.83*	.07	-.13	-.08	.72
28.	Math confidence	-.10	-.05	.90*	.01	.02	.04	.83
Latent root, Variance								
Eigenvalues		7.65	5.25	3.17	2.75	1.19	1.19	21.20
Percentage Variance		27.69	18.75	11.32	9.82	4.25	4.25	76.08

*Factor Loadings Cut off at .40

Table 6

Factor One - Personal Effectiveness

Scale Number	Scale Description	Factor Loading	h^2
4	Unfavorable Adjectives	-.71	.55
5	Defensiveness	.87	.82
7	Self-Control	.80	.77
9	Personal Adjustment	.86	.75
10	Achievement	.53	.82
12	Endurance	.72	.86
13	Order	.68	.77
14	Intraception	.81	.69
15	Nurturance	.87	.86
16	Affiliation	.79	.85
19	Autonomy	-.55	.81
20	Aggression	-.79	.87
23	Deference	.59	.87

included those characteristics which require self-control, cheerfulness, interest in others, and provides nurturance to others. The negative loadings of this factor were characterized by number of unfavorable adjectives, and indicated a tendency to engage in behaviors which attack or hurt others. Values indicate that individuals loading high on Factor One do not possess the negative characteristics. Factor One is principally an ACL factor reflecting personal effectiveness.

Factor Two accounts for 18.75 percent of the common variance. This factor includes 9 of the 21 ACL items. Autonomy and aggression, which loaded positively on the Factor Two, are also included in Factor One. The highest factor loading on Factor Two is dominance (.89). Students rated high on need for dominance and need for achievement and self-confidence. They were characterized by seeking leadership roles and striving to be outstanding in groups. Factor Two was labeled "Assertiveness".

Factor Three, Mathematics Anxiety, accounts for 11.32 percent of the common variance and includes four of the five mathematics attitude scales, namely, usefulness, mathematics anxiety scale, effectiveness, and mathematics confidence. The fact that these items loaded so heavily on a single factor indicates that mathematics anxiety may be viewed as a unidimensional phenomenon influenced by a student's degree of confidence, motivation, and the degree to which he or she considers mathematics to be useful. In addition, Test anxiety loaded on this factor but somewhat less strongly than the

Table 7
Factor Two - Assertiveness

Scale Number	Scale Description	Factor Loading	h^2
6	Self Confidence	.85	.77
10	Achievement	.70	.82
11	Dominance	.89	.92
18	Exhibition	.68	.74
19	Autonomy	.65	.81
20	Aggression	.47	.87
22	Succorance	-.63	.65
23	Deference	-.68	.87
24	Abasement	-.88	.82

Table 8

Factor Three - Mathematics Anxiety

Scale Number	Scale Description	Factor Loading	h^2
1	Usefulness	.69	.52
2	Text Anxiety	.53	.66
3	Mathematics Anxiety	.89	.84
27	Effectance	.83	.72
28	Mathematics Confidence	.90	.83

mathematics attitudes variables. Factor loadings on Factor Three thus help establish the construct validity of mathematics anxiety.

Factor Four includes 7 ACL items of the 21 ACL items. Factor Four accounts for 9.82 percent of the common variance. Factor Four was characterized by high positive loadings for lability, need for change and need for heterosexuality. The highest loading (.79) is on lability seen favorably as spontaneous, but unfavorably as restless and nervous. Factor Four was labeled "Outgoingness".

Factor Five, Success, accounts for 4.25 percent of the common variance and includes only the success scale with a factor loading of -.77.

Factor Six includes only the dogmatism and test anxiety scales and accounts for 4.25 percent of the common variance.

The results of the factor analysis, Factor Three, suggest that mathematics anxiety is a unidimensional construct related more strongly to students' attitudes towards mathematics than it is to their personality characteristics. Whether students can accurately be described as assertive, dominant, or dogmatic does not appear to be a predictor of whether or not they will experience mathematics anxiety. However, if students indicate negative attitudes towards mathematics, and if they lack confidence in learning it, they are likely to experience mathematics anxiety, a condition impairing their ability to learn and thus achieve success in mathematics-related curricula.

Table 12 presents a matrix of intercorrelations between six personal data items and six extracted factors. Five of these correlations are significant statistically ($p < .05$) and provide useful information:

Table 9
Factor Four - Outgoingness

Scale Number	Scale Description	Factor Loading	h^2
8	Lability	.79	.65
12	Endurance	-.44	.86
13	Order	-.47	.77
16	Affiliation	.45	.85
17	Heterosexuality	.64	.63
18	Exhibition	.41	.74
21	Change	.75	.68

Table 10

Factor Five - Success

Scale Number	Scale Description	Factor Loading	h^2
26	Success	-.77	.63

Table 11

Factor Six - Dogmatism

Scale Number	Scale Description	Factor Loading	h^2
2	Text Anxiety	.46	.66
25	Dogmatism	.88	.83

Table 12
Correlation Coefficients Between Personal Data and Factor Scores

Personal Data	Factor 1 Effectiveness	Factor 2 Assertiveness	Factor 3 Math Anxiety	Factor 4 Outgoingness	Factor 5 Success	Factor 6 Dogmatism
SES (N=225)	.03	-.08	-.11	-.08	.04	.22*
QROM (N=214)	-.04	-.001	-.10	-.06	-.04	-.04
HSMath (N=228)	-.01	-.01	-.44*	-.08	-.04	.01
Sex (N=228)	-.11	.05	.08	.09	.21*	-.19
QCA (N=227)	-.19	-.07	.28*	.12	.15	.17
CRSGrade (N=227)	.12	.07	-.54*	-.17	-.02	-.03

* Significant Values ($p < .05$)

1. A negative correlation ($-.54$) between course grade in mathematics and the Mathematics Anxiety Factor suggests that students who experience high anxiety in mathematics courses will tend not to perform well in these courses.
2. A negative correlation ($-.44$) between the level of mathematics completed in high school and mathematics anxiety suggests that mathematics anxiety may lead students to avoid further mathematics courses.
3. There is a weak positive correlation ($.28$) between mathematics anxiety and QCA, suggesting that students who experience mathematics anxiety tend to get low grades in other courses.¹
4. Sex does seem to be related to student attitudes towards mathematics. Although the relationship is weak, the correlation ($.21$) between sex and attitude towards success indicates that females tend to be less interested than males in being successful in mathematics.¹
5. There is a weak positive relationship ($.22$) between SES and dogmatism, Factor Six, an indication that students whose parents have achieved a high level of education tend to be less dogmatic.¹

¹Because the coding procedures used in the study were unique the reader might be led to believe that the values contained in Table 12 were interpreted incorrectly. Be assured that the statements made in the paragraphs numbered 3, 4 and 5 are consistent with the findings reported in that table.

Summary

The purpose of this study was to investigate the extent to which distinct attitudes toward mathematics can be viewed as reflection of a variety of personal characteristics as opposed to manifestation of a single underlying attitude about mathematics. More specifically, it sought to establish the validity of the construct, mathematics anxiety, and to the scales used to measure it; to investigate the possibility that mathematics anxiety may be a multidimensional construct, and to determine the strength of the relationship between factors describing mathematics anxiety and other variables, including dogmatism.

A series of eight survey instruments and five personal data questions (sex, socio-economic status, college grade point level, college curriculum and high school mathematics background) were administered in 17 freshman college mathematics classes having a total of 491 students. In addition, achievement (grade) on the mathematics courses was obtained for each student. Factor analysis techniques were used to treat the data. Firstly, the scores from the eight tests were analyzed to reduce the responses to six principal factors, one of which characterized mathematics anxiety. Secondly, the strength of the relationships of these factors to the six personal data including achievement was determined. The results of the factor analysis suggest that mathematics anxiety is essentially a unidimensional construct related more strongly to students' attitudes toward mathematics than to their personality characteristics. One factor, named the

Mathematics Anxiety Factor, includes four mathematics attitude scales: Usefulness of Mathematics, Mathematics Anxiety, Effectance Motivation in Mathematics and Confidence in Learning Mathematics. That these scales loaded so heavily in a single factor indicates that mathematics anxiety may be viewed as a unidimensional construct. Factor loadings on the Mathematics Anxiety Factor also helped establish the construct validity of mathematics anxiety. In addition, mathematics achievement and high school mathematics background are substantially related to mathematics anxiety. They are negatively related to mathematics anxiety.

Conclusion

The most important findings of this study are that the mathematics anxiety is unidimensional in nature; that it is a valid construct; and that it appears to be influenced by related student attitudes. Mathematics anxiety appears to be a self-perpetuating problem which is related to mathematics achievement and high school mathematics background. In addition, mathematics anxiety may influence the extent of high school preparation which in turn influences college achievement; students who have not taken many mathematics courses in high school may already suffer from mathematics anxiety.

Another important finding is the apparent lack of relationship between sex and mathematics anxiety coupled with a slight but significant relationship between sex and attitude towards success in mathematics. Females tend to be reluctant to be seen as successful

mathematics students, an attitude which may lead them to avoid mathematics-related curricula quite apart from the effect of mathematics anxiety. This outcome definitely suggests that a tendency to view success in mathematics negatively may have been classified superficially as mathematics anxiety in the many, largely anecdotal studies reviewed in Chapter 2. However, the effect on females would be the same, leading to self-selection out of those professions traditionally dominated by males: engineering and the physical sciences. In this study, most students are majors in arts, social science, education, business, and home economics. For engineering and physical sciences students, the study might have yielded different results. In addition for this study, sex does not appear to be related to mathematics achievement, a finding which also contradicts many current theories about why females tend to do poorly in mathematics courses.

Recommendations

The findings just reported lead to several recommendations. The first concerns the need to prevent the development of mathematics anxiety. The complex of variables that appears to define this construct includes only two that seem basically superficial and might be manipulated by teachers, namely, Usefulness of Mathematics and Effectance Motivation. Moreover, this manipulation should occur early in schooling, since it appears that a tendency toward mathematics anxiety is fully established by the time a student reaches high school. Therefore:

Elementary and middle or junior high school teachers should emphasize the importance of mathematics and the enjoyment that can be attained in mathematics.

The second recommendation pertains especially to female students at all educational levels. It was found that, unrelated to mathematics anxiety, females tended to view success in mathematics more negatively than males. Certainly this tendency could lead to lower mathematics achievement quite apart from any affect of mathematics anxiety. Therefore:

Students at all levels, but especially females, should be encouraged to achieve maximum success in mathematics.

Regardless of the measures just recommended, mathematics anxiety is likely to remain somewhat prevalent among high school and college students. This statement follows because of its apparent relationship to ability and the natural tendency of students to be apprehensive concerning academic work they find difficult. Therefore:

In both high schools and colleges, students with mathematics anxiety should be identified and programs should be developed and implemented to help them overcome it.

Finally, limitations on the research reported above lead to a recommendation for further research. Specifically, it was noted that the subjects of the present study were from a single university and were largely limited to those in arts, social sciences, business, education and home economics. Therefore:

Researchers should investigate attitudes toward mathematics in a variety of postsecondary settings but especially among students in engineering and the physical sciences. This research should emphasize the effects of admissions criteria and self-selection into curricular requiring more or less course work in mathematics.

REFERENCES

- Aiken, L. R., Jr. Attitudes toward mathematics. Review of Educational Research, 1970, 40, 555-596.
- Aiken, L. R., Jr. Sex differences in attitude and achievement. Washington, D. C., United States Office of Education, 1971. (ERIC Document Reproduction Service No. ED 049 922.)
- Aiken, L. R., Jr. Research on attitudes toward math. Arithmetic Teacher, 1972, 19, 229-234.
- Aiken, L. R., Jr. Update on attitudes and other affective variables in learning mathematics. Review of Educational Research, 1976, 46, 293-311.
- Aiken, L. R., Jr. & Dreger, R. M. The effect of attitudes on performance in mathematics. Journal of Educational Psychology, 1961, 52, 19-24.
- Anttonen, R. G. A longitudinal study in mathematics attitude. Journal of Educational Research, 1969, 62, 471-477.
- Biggs, J. B. The psychopathology of arithmetic. In F. W. Land (Ed.), New Approaches to Mathematics Teaching. New York: St. Martin's Press, Inc., 1965.
- Callahan, L. G., & Glennon, V. J. Elementary school math: A guide to current research. Washington, D. C., Association for Supervision and Curriculum Development, 1975.
- Carroll, J. B. Factors of verbal achievement. In Ann Anastasi (Ed.), Testing problems in perspective. Washington, D. C., American Council on Education, 1966, p. 406.
- Dreger, R. M., & Aiken, L. R. The identification of number anxiety in college populations. Journal of Educational Psychology, 1958, 48, 344-351.
- Feldhusen, J. M. Anxiety, divergent thinking, and achievement. Journal of Educational Psychology, 1965, 56, 40-45.
- Fennema, E. What difference does it make? (If boys learn math better than girls). Wisconsin Teacher of Math, 1974, 25, 6-7.

- Fennema, E. Mathematics learning and the sexes: A review. Journal of Research of Mathematical Education, 1974, 5, 126-130.
- Fennema, E., & Sherman, J. A. Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by males and females, Catalog of Selected Documents in Psychology, 1976, 6, p. 31.
- Fennema, E., & Sherman, J. A. Sex-Related differences in mathematics achievement, spatial visualization and affective factors, American Research Journal, 1977, 14, 51-71.
- Frary, R. B. Comprehensive Questionnaire Analysis Program, (FORTRAN IV), Learning Resources Center, Virginia Polytechnic Institute and State University, 1974.
- Fruchter, B. F., Rokeach, M., & Novak, E. D. A factorial study of dogmatism, opinionation, and related scales. Psychological Reports, 1958, 4, 19-22.
- Giles, M. B. Personal Communication, October 22, 1981.
- Glennon, V. J., & Callahan, L. G. Elementary School Mathematics, A Guide to Current Research, NEA, Washington, D. C., 1968.
- Gough, H. G. The Adjective Check List. Consulting Psychologists Press, Palo Alto, CA, 1952.
- Gough, H. G. & Heilbrum, A. B., Jr. The Adjective Check List Manual. Consulting Psychologists Press, Palo Alto, CA, 1965.
- Hendel, D. D. The math anxiety program: Its genesis and evaluation in continuing education for women. University of Minnesota, MN, 1977.
- Hilton, T. L., & Berglund, G. W. Sex differences in mathematics achievement - A longitudinal study. Journal of Educational Research, 1974, 67, 231-237.
- Kogelman, S., Nigro, E., & Warren, J. Mind over math: Overcoming math anxiety at the Dalton School. Independent School, 1978, 4, 44-46.
- Liebert, R. M., & Morris, L. W. Cognitive and emotional components of test anxiety: A distinction and some initial data. Psychological Reports, 1967, 20, 957-978.
- MacCoby, E. E., & Jacklin, C. N. The psychology of sex differences. Palo Alto: Stanford University Press, 1974.

- Mager, R. F. Developing attitude toward learning. Palo Alto, CA, Pearson Publishers, 1968.
- Mathison, M. A. Curriculum interventions and programming innovations for the reduction of mathematics anxiety. A paper presented at the Annual Convention of the American Psychological Association, San Francisco, CA, 1977, 26-30.
- McCandless, B. R., & Castaneda, A. Anxiety in children, school achievement, and intelligence. Child Development, 1956, 27, 378-382.
- Mehrens, W. A., & Lehmann, I. J. Standardized Tests in Education, New York: Holt, Rinehart and Winston, Inc., 1969.
- Neale, D. C. The role of attitudes in learning math. Arithmetic Teacher, 1969, 16, 631-640.
- Philips, B. N. Sex, social class, and anxiety as sources of variation in school achievement. Journal of Educational Psychology, 1962, 53, 316-322.
- Poffenberger, T., & Norton, D. Factors in the Formation of Attitudes Toward Mathematics. Journal of Educational Research, 1959, 52, 26-33.
- Rokeach, M. Political and religious dogmatism: An alternative to the authoritarian personality. Psychological Monographs, 1956, 43, p. 70.
- Rokeach, M. The open and closed mind: Investigations into the nature of belief systems and personality systems. New York: Basic Books, Inc., 1960.
- SAS Institute, Inc. SAS User's Guide 1976 Edition. Raleigh, NC: SAS Institute, Inc., 1976.
- Scandura, J. M. (Ed.) Research in mathematics education. National Council of Teachers of Mathematics, 1967.
- Sells, L. W. The Mathematical Filter and the Education of Women and Minorities. U. S. Educational Resources Information Center, 1976. (ERIC Document Reproduction Service No. ED 121 633.)
- Sherman, J. Effects of biological factors on sex-related differences in mathematics achievement. Prepared for The National Institute of Educational Research, Fall, 1976.

- Sherman, J., & Fennema, E. The study of mathematics by high school girls and boys: Related variables. American Educational Research, 1977, 14, 159-168.
- Spielberger, C. D. Test anxiety inventory. University of South Florida, 1978.
- Suydam, M. N., & Weaver, J. F. Using research: A key to elementary school math. Columbus, OH: ERIC Science, Mathematics and environmental Education Clearinghouse, in cooperation with the Center for Science and Mathematics Education, 1975.
- Tobias, S. Why Janie can't - or won't - do math? Independent School, 1978a, 37, 42-43.
- Tobias, S. Overcoming math anxiety. New York: W. W. Norton and Company, Inc., 1978b.
- Troldahl, V. C., & Powell, F. A. A short-form dogmatism scale for use in field studies. Social Forces, 1965, 44, 221-224.
- Wilson, J. W. Patterns of mathematics achievement in grade 11: Z population. National Longitudinal Study of Mathematics Abilities, Report No. 17, School Mathematics Study Group, Standford, CA, 1972.

APPENDIX A

MATRIX OF INTERCORRELATIONS AMONG
VARIABLES OF THE STUDY

APPENDIX A

Matrix of Intercorrelations among Variables of the Study

Variables	Correlation																																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33		
Usefulness	1																																		
Text Anxiety	2	18																																	
Math Anxiety	3	48	57																																
Unfavorable adj.	4	-00	02	10																															
Defensiveness	5	-06	-01	-14	-54																														
Self-confidence	6	01	11	-08	-12	27																													
Self-control	7	-05	01	-07	54	63	-09																												
Lability	8	07	-01	01	10	05	17	-21																											
Personal adj.	9	-03	-04	-12	-57	74	17	63	07																										
Achievement	10	-13	-14	-22	-40	59	63	34	01	48																									
Dominance	11	-05	-17	-21	-28	48	76	08	07	33	83																								
Endurance	12	-11	-07	-17	-53	68	30	64	-28	57	73	56																							
Order	13	-13	-08	-16	-42	62	19	66	-30	59	63	43	85																						
Intracception	14	-07	-04	-13	-49	70	09	56	15	72	40	23	51	55																					
Nurturance	15	-03	11	-04	-61	74	01	60	15	71	31	17	46	38	74																				
Affiliation	16	-05	03	-10	-43	77	26	45	28	71	45	38	40	36	66	80																			
Heterosexuality	17	02	03	-11	-21	37	34	06	37	33	30	35	11	08	25	45	60																		
Exhibition	18	01	-09	-12	17	-05	65	-46	26	-13	27	56	-11	-17	-19	-15	10	37																	
Autonomy	19	06	-17	-03	41	-31	47	-60	25	-38	11	36	-28	-28	-12	-53	-25	06	60																
Aggression	20	04	-07	01	54	-57	32	-69	01	-59	-06	18	-35	-34	-64	-78	-59	-15	54	70															
Change	21	05	-03	-00	00	06	32	-30	55	01	17	25	-25	-27	04	06	28	43	44	43	17														
Deference	22	-07	15	01	-35	35	-52	64	-24	42	-11	-37	25	32	39	57	33	-01	-63	-86	-74	-43													
Succorance	23	-09	16	11	38	-34	-49	-13	-09	-32	-46	-61	-34	-23	-26	-17	-30	-15	-21	-30	06	-21	29												
Abasement	24	-02	22	14	03	-08	-68	26	-12	02	-48	-74	-15	-07	08	21	-05	-14	-63	-66	-44	-31	69	63											
Dogmatism	25	-00	-16	01	-01	-07	10	-08	02	02	-03	-01	-03	-03	02	-02	-03	07	12	12	04	14	-11	-04	-03										
Success	26	09	-04	05	-03	02	-05	-01	-05	-00	-03	-05	01	03	08	03	-01	-00	-05	-04	-10	-01	-01	-09	00	-09									
Effectance	27	50	25	64	07	-08	-04	-05	07	-10	-22	-18	-16	-14	-07	-01	-04	01	-06	01	00	09	-01	02	10	04	16								
Math Confidence	28	50	42	82	10	-13	-03	-14	05	-12	-24	-17	-18	-18	-14	-05	-13	-06	-05	01	04	03	-04	06	10	-01	08	73							
SES	29	-11	05	-05	-09	-01	-06	-06	-09	-05	-00	03	05	02	-02	04	-06	-03	01	-11	-03	-20	12	01	01	-25	07	-06	-06						
QROM	30	-11	-11	-14	02	01	11	06	01	03	03	05	07	10	06	-05	-04	-07	02	-00	07	-02	-02	03	-01	02	-02	-10	-11	-06					
MSMath	31	-25	-24	-42	07	00	-02	08	-08	00	05	02	10	10	-00	-03	01	-06	-05	-00	01	-09	01	-03	00	-04	-02	-36	-48	01	06				
Sex	32	13	10	16	07	-11	12	-06	01	-02	-12	-03	-16	-11	-08	-13	-14	01	11	19	22	16	-16	10	-05	13	-22	02	12	-14	10	-11			
QCA	33	07	37	36	11	-13	-07	-16	11	-11	-17	-14	-21	-18	-09	-05	-04	07	02	04	03	04	-01	07	05	-09	01	22	33	16	-11	-20	-10		
Course Grade	34	-29	-26	-49	-05	06	-01	17	-11	10	17	09	18	23	09	-06	-05	-14	-04	-03	04	-07	03	03	-05	-03	-09	-44	-52	04	02	36	06	-37	

Decimal points omitted

Quantitative Requirement of Major (QROM)

APPENDIX B

INSTRUMENTS

The Adjective Check List

Instructions: Please read a list of 300 adjectives quickly and blacken in the number beside each one you would consider to be self-descriptive. Do not worry about duplications, contradictions, and so forth. Try to be frank, and dark the numbers for the adjectives which describe you as you really are, not as you would like to be.

- | | | |
|-------------------|--------------------|-------------------|
| 1. Absent-minded | 31. Cheerful | 61. Dependent |
| 2. Active | 32. Civilized | 62. Despondent |
| 3. Adaptable | 33. Clear-thinking | 63. Determined |
| 4. Adventurous | 34. Clever | 64. Dignified |
| 5. Affected | 35. Coarse | 65. Discreet |
| 6. Affectionate | 36. Cold | 66. Disorderly |
| 7. Aggressive | 37. Commonplace | 67. Dissatisfied |
| 8. Alert | 38. Complaining | 68. Distractible |
| 9. Aloof | 39. Complicated | 69. Distrustful |
| 10. Ambitious | 40. Conceited | 70. Dominant |
| 11. Anxious | 41. Confident | 71. Dreamy |
| 12. Apathetic | 42. Confused | 72. Dull |
| 13. Appreciative | 43. Conscientious | 73. Easy-going |
| 14. Argumentative | 44. Conservative | 74. Effeminate |
| 15. Arrogant | 45. Considerate | 75. Efficient |
| 16. Artistic | 46. Contented | 76. Egotistical |
| 17. Assertive | 47. Conventional | 77. Emotional |
| 18. Attractive | 48. Cool | 78. Energetic |
| 19. Autocratic | 49. Cooperative | 79. Enterprising |
| 20. Awkward | 50. Courageous | 80. Enthusiastic |
| 21. Bitter | 51. Cowardly | 81. Evasive |
| 22. Blustery | 52. Cruel | 82. Excitable |
| 23. Boastful | 53. Curious | 83. Fair-minded |
| 24. Bossy | 54. Cynical | 84. Fault-finding |
| 25. Calm | 55. Daring | 85. Fearful |
| 26. Capable | 56. Deceitful | 86. Feminine |
| 27. Careless | 57. Defensive | 87. Fickle |
| 28. Cautious | 58. Deliberate | 88. Flirtatious |
| 29. Changeable | 59. Demanding | 89. Foolish |
| 30. Charming | 60. Dependable | 90. Forceful |

The Adjective Check List, continued

91. Foresighted	131. Insightful	171. Peaceable
92. Forgetful	132. Intelligent	172. Peculiar
93. Forgiving	133. Interests narrow	173. Persevering
94. Formal	134. Interests wide	174. Persistent
95. Frank	135. Intolerant	175. Pessimistic
96. Friendly	136. Inventive	176. Planful
97. Frivolous	137. Irresponsible	177. Pleasant
98. Fussy	138. Irritable	178. Pleasure-seeking
99. Generous	139. Jolly	179. Poised.
100. Gentle	140. Kind	180. Polished.
101. Gloomy	141. Lazy	181. Practical
102. Good-looking	142. Leisurely	182. Praising
103. Good-natured	143. Logical	183. Precise
104. Greedy	144. Loud	184. Prejudiced
105. Handsome	145. Loyal	185. Preoccupied
106. Hard-headed	146. Mannerly	186. Progressive
107. Hard-hearted	147. Masculine	187. Prudish
108. Hasty	148. Mature	188. Quarrelsome
109. Headstrong	149. Meek	189. Queer
110. Healthy	150. Methodical	190. Quick
111. Helpful	151. Mild	191. Quiet
112. High-strung	152. Mischievous	192. Quitting
113. Honest	153. Moderate	193. Rational
114. Hostile	154. Modest	194. Rattlebrained
115. Humorous	155. Moody	195. Realistic
116. Hurried	156. Nagging	196. Reasonable
117. Idealistic	157. Natural	197. Rebellious
118. Imaginative	158. Nervous	198. Reckless
119. Immature	159. Noisy	199. Reflective
120. Impatient	160. Obliging	200. Relaxed
121. Impulsive	161. Obnoxious	201. Reliable
122. Independent	162. Opinionated	202. Resentful
123. Indifferent	163. Opportunistic	203. Reserved
124. Individualistic	164. Optimistic	204. Resourceful
125. Industrious	165. Organized	205. Responsible
126. Infantile	166. Original	206. Restless
127. Informal	167. Outgoing	207. Retiring
128. Ingenious	168. Outspoken	208. Rigid
129. Inhibited	169. Painstaking	209. Robust
130. Initiative	170. Patient	210. Rude

The Adjective Check List, continued

211. Sarcastic	251. Strong	291. Warm
212. Self-centered	252. Stubborn	292. Wary
213. Self-confident	253. Submissive	293. Weak
214. Self-controlled	254. Suggestible	294. Whiny
215. Self-denying	255. Sulky	295. Wholesome
216. Self-pitying	256. Superstitious	296. Wise
217. Self-punishing	257. Suspicious	297. Withdrawn
218. Self-seeking	258. Sympathetic	298. Witty
219. Selfish	259. Tactful	299. Worrying
220. Sensitive	260. Tactless	300. Zany
221. Sentimental	261. Talkative	
222. Serious	262. Temperamental	
223. Severe	263. Tense	
224. Sexy	264. Thankless	
225. Shallow	265. Thorough	
226. Sharp-witted	266. Thoughtful	
227. Shiftless	267. Thrifty	
228. Show-off	268. Timid	
229. Shrewd	269. Tolerant	
230. Shy	270. Touchy	
231. Silent	271. Tough	
232. Simple	272. Trusting	
233. Sincere	273. Unaffected	
234. Slipshod	274. Unambitious	
235. Slow	275. Unassuming	
236. Sly	276. Unconventional	
237. Smug	277. Undependable	
238. Snobbish	278. Understanding	
239. Sociable	279. Unemotional	
240. Soft-hearted	280. Unexcitable	
241. Sophisticated	281. Unfriendly	
242. Spendthrift	282. Uninhibited	
243. Spineless	283. Unintelligent	
244. Spontaneous	284. Unkind	
245. Spunky	285. Unrealistic	
246. Stable	286. Unscrupulous	
247. Steady	287. Unselfish	
248. Stern	288. Unstable	
249. Stingy	289. Vindictive	
250. Stolid	290. Versatile	

Short-Form Dogmatism Scale

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | | | | |
|---|---|---|---|---|
| 1. In this complicated world of ours the only way we can know what's going on is to rely on leaders or experts who can be trusted. | 1 | 2 | 3 | 4 |
| 2. My blood boils whenever a person stubbornly refuses to admit he's wrong. | 1 | 2 | 3 | 4 |
| 3. There are two kinds of people in this world: those who are for the truth and those who are against the truth. | 1 | 2 | 3 | 4 |
| 4. Most people just don't know what's good for them. | 1 | 2 | 3 | 4 |
| 5. Of all the different philosophies which exist in the world there is probably only one which is correct. | 1 | 2 | 3 | 4 |
| 6. The highest form of government is a democracy and the highest form of democracy is a government run by those who are most intelligent. | 1 | 2 | 3 | 4 |
| 7. The main thing in life is for a person to want to do something important. | 1 | 2 | 3 | 4 |
| 8. I'd like it if I could find someone who would tell me how to solve my personal problems. | 1 | 2 | 3 | 4 |
| 9. Most of the ideas which get printed nowadays aren't worth the paper they are printed on. | 1 | 2 | 3 | 4 |

Short-Form Dogmatism Scale, continued

- | | | | | |
|---|---|---|---|---|
| 10. Man on his own is a helpless and miserable creature. | 1 | 2 | 3 | 4 |
| 11. It is only when a person devotes himself to an ideal or cause that life becomes meaningful. | 1 | 2 | 3 | 4 |
| 12. Most people just don't give a "dam" for others. | 1 | 2 | 3 | 4 |
| 13. To compromise with our political opponents is dangerous because it usually leads to the betrayal of our own side. | 1 | 2 | 3 | 4 |
| 14. It is often desirable to reserve judgment about what's going on until one has had a chance to hear the opinions of those one respects. | 1 | 2 | 3 | 4 |
| 15. The present is all too often full of unhappiness. It is only the future that counts. | 1 | 2 | 3 | 4 |
| 16. The United States and Russia have just about nothing in common. | 1 | 2 | 3 | 4 |
| 17. In a discussion I often find it necessary to repeat myself several times to make sure I am being understood. | 1 | 2 | 3 | 4 |
| 18. While I don't like to admit this even to myself, my secret ambition is to become a great person, like Einstein, or Beethoven, or Shakespeare. | 1 | 2 | 3 | 4 |
| 19. Even though freedom of speech for all groups is a worthwhile goal, it is unfortunately necessary to restrict the freedom of certain political groups. | 1 | 2 | 3 | 4 |
| 20. It is better to be a dead hero than to be a live coward. | 1 | 2 | 3 | 4 |

Test Anxiety Inventory

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | | | | |
|---|---|---|---|---|
| 1. I feel confident and relaxed while taking examinations. | 1 | 2 | 3 | 4 |
| 2. Thinking about the grade interferes with my work on exams. | 1 | 2 | 3 | 4 |
| 3. While taking exams I have an uneasy, upset feeling. | 1 | 2 | 3 | 4 |
| 4. I freeze up on examinations. | 1 | 2 | 3 | 4 |
| 5. During exams I doubt whether I'll ever get through college. | 1 | 2 | 3 | 4 |
| 6. The harder I work at taking an exam the more confused I get. | 1 | 2 | 3 | 4 |
| 7. Thoughts of doing poorly interfere with my concentration. | 1 | 2 | 3 | 4 |
| 8. I feel very nervous when taking an examination. | 1 | 2 | 3 | 4 |
| 9. Even if I'm prepared for an exam I feel anxious about it. | 1 | 2 | 3 | 4 |
| 10. I feel very uneasy just before getting an exam paper back. | 1 | 2 | 3 | 4 |
| 11. During examinations I feel very tense. | 1 | 2 | 3 | 4 |
| 12. I wish examinations did not bother me so much. | 1 | 2 | 3 | 4 |

Text Anxiety Inventory, continued

- | | | | | |
|--|---|---|---|---|
| 13. During exams I am so tense that my stomach gets upset. | 1 | 2 | 3 | 4 |
| 14. I seem to defeat myself while working on examinations. | 1 | 2 | 3 | 4 |
| 15. I feel very panicky when I take examinations. | 1 | 2 | 3 | 4 |
| 16. During exams I think about the consequences of failing. | 1 | 2 | 3 | 4 |
| 17. I feel my heart beating very fast during examinations. | 1 | 2 | 3 | 4 |
| 18. During exams I get so nervous that I forget facts I know. | 1 | 2 | 3 | 4 |
| 19. I worry a great deal before taking an examination. | 1 | 2 | 3 | 4 |
| 20. As soon as an examination is over I try to stop worrying about it, but I just can't. | 1 | 2 | 3 | 4 |

"Mathematics Anxiety" Scale

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | | | | |
|---|---|---|---|---|
| 1. I usually have been at ease in math classes. | 1 | 2 | 3 | 4 |
| 2. Mathematics usually makes me feel uncomfortable and nervous. | 1 | 2 | 3 | 4 |
| 3. I get a sinking feeling when I think of trying hard math problems. | 1 | 2 | 3 | 4 |
| 4. Math doesn't scare me at all. | 1 | 2 | 3 | 4 |
| 5. It wouldn't bother me at all to take more math courses. | 1 | 2 | 3 | 4 |
| 6. My mind goes blank and I am unable to think clearly when working with math. | 1 | 2 | 3 | 4 |
| 7. I usually have been at ease during math tests. | 1 | 2 | 3 | 4 |
| 8. Mathematics makes me feel uncomfortable, restless, irritable, and impatient. | 1 | 2 | 3 | 4 |
| 9. The thought of a math test scares me. | 1 | 2 | 3 | 4 |
| 10. Mathematics makes me feel uneasy and confused. | 1 | 2 | 3 | 4 |
| 11. I almost never have gotten really upset during a math test. | 1 | 2 | 3 | 4 |
| 12. I haven't usually worried about being able to solve math problems. | 1 | 2 | 3 | 4 |

Attitude Toward Success in Mathematics Scale

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | |
|--|---------------|
| 1. It would make me happy to be recognized as an excellent student in mathematics. | 1 2 3 4 |
| 2. Winning a prize in mathematics would make me feel unpleasantly conspicuous. | 1 2 3 4 |
| 3. People would think I was some kind of a "grind" if I got A's in math. | 1 2 3 4 |
| 4. I'd be proud to be the outstanding student in math. | 1 2 3 4 |
| 5. If I had good grades in math, I would try to hide it. | 1 2 3 4 |
| 6. If I got the highest grade in math, I'd prefer no one knew. | 1 2 3 4 |
| 7. I'd be happy to get top grades in mathematics. | 1 2 3 4 |
| 8. It would make people like me less if I were a really good math student. | 1 2 3 4 |
| 9. It would be really great to win a prize in mathematics. | 1 2 3 4 |
| 10. Being first in a mathematics competition would make me pleased. | 1 2 3 4 |
| 11. I don't like people to think I'm smart in math. | 1 2 3 4 |
| 12. Being regarded as smart in mathematics would be a great thing. | 1 2 3 4 |

Effectance Motivation in Mathematics Scale

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | | | | |
|---|---|---|---|---|
| 1. I like math puzzles. | 1 | 2 | 3 | 4 |
| 2. Mathematics is enjoyable and stimulating to me. | 1 | 2 | 3 | 4 |
| 3. Figuring out mathematical problems does not appeal to me. | 1 | 2 | 3 | 4 |
| 4. Once I start trying to work on a math puzzle, I find it hard to stop. | 1 | 2 | 3 | 4 |
| 5. Math puzzles are boring. | 1 | 2 | 3 | 4 |
| 6. I would rather have someone give me the solution to a difficult math problem than to have to work it out for myself. | 1 | 2 | 3 | 4 |
| 7. I do as little work in math as possible. | 1 | 2 | 3 | 4 |
| 8. When a math problem arises that I can't immediately solve, I stick with it until I have the solution. | 1 | 2 | 3 | 4 |
| 9. When a question is left unanswered in math class, I continue to think about it afterward. | 1 | 2 | 3 | 4 |
| 10. I am challenged by math problems I can't understand immediately. | 1 | 2 | 3 | 4 |

Effectance Motivation in Mathematics Scale, continued

- | | | | | |
|---|---|---|---|---|
| 11. The challenge of math problems does not appeal to me. | 1 | 2 | 3 | 4 |
| 12. I don't understand how some people can spend so much time on math and seem to enjoy it. | 1 | 2 | 3 | 4 |

Usefulness of Mathematics Scale

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | | | | |
|---|---|---|---|---|
| 1. Knowing mathematics will help me earn a living. | 1 | 2 | 3 | 4 |
| 2. I expect to have little use for mathematics when I get out of school. | 1 | 2 | 3 | 4 |
| 3. Mathematics will not be important to me in my life's work. | 1 | 2 | 3 | 4 |
| 4. I see mathematics as a subject I will rarely use in my daily life after leaving college. | 1 | 2 | 3 | 4 |
| 5. I'll need mathematics for my future work. | 1 | 2 | 3 | 4 |
| 6. Taking mathematics is a waste of time. | 1 | 2 | 3 | 4 |
| 7. I will use mathematics in many ways in the future. | 1 | 2 | 3 | 4 |
| 8. I'll need a firm mastery of mathematics for my future work. | 1 | 2 | 3 | 4 |
| 9. In terms of my future plans, it is not important for me to do well in mathematics. | 1 | 2 | 3 | 4 |
| 10. I study mathematics because I know how useful it is. | 1 | 2 | 3 | 4 |
| 11. Mathematics is a worthwhile and necessary subject. | 1 | 2 | 3 | 4 |
| 12. Mathematics is of no relevance to my life. | 1 | 2 | 3 | 4 |

Confidence in Learning Mathematics Scale

Instructions: Please answer the questions below by marking the appropriate column according to the following scale:

1. Agree
2. Tend to agree
3. Tend to disagree
4. Disagree

Please be sure that question and answer numbers match.

- | | | | | |
|---|---|---|---|---|
| 1. Generally, I have felt secure about attempting mathematics. | 1 | 2 | 3 | 4 |
| 2. I am sure I could do advanced work in math. | 1 | 2 | 3 | 4 |
| 3. For some reason, even though I study, math seems unusually hard for me. | 1 | 2 | 3 | 4 |
| 4. I think I could handle more difficult mathematics. | 1 | 2 | 3 | 4 |
| 5. I don't think I could do advanced mathematics. | 1 | 2 | 3 | 4 |
| 6. I'm no good in math. | 1 | 2 | 3 | 4 |
| 7. I am sure that I can learn mathematics. | 1 | 2 | 3 | 4 |
| 8. I'm not the type to do well in math. | 1 | 2 | 3 | 4 |
| 9. I can get good grades in mathematics. | 1 | 2 | 3 | 4 |
| 10. I have a lot of self-confidence when it comes to math. | 1 | 2 | 3 | 4 |
| 11. Most subjects I can handle O.K., but I have a knack for flubbing up math. | 1 | 2 | 3 | 4 |
| 12. Math has been my worst subject. | 1 | 2 | 3 | 4 |

Personal Data

Instructions: Please answer the questions by blackening the appropriate number.

1. Father's occupation (mother's or guardian's if father is absent).
 1. Professional/managerial (usually requires Bach. Deg. or more).
 2. White collar/skilled trade (substantial training required).
 3. Nonskilled (only short term training required).
2. What is your major?
 1. Physical science or engineering.
 2. Biology or biochemistry.
 3. Agriculture (include forestry, wildlife).
 4. Arts (history, English, languages, etc.).
 5. Social Science (psychology, geography, political science).
 6. Math Science (math, computer science, statistics).
 7. Education.
 8. Business.
 9. Home Economics.
 10. Architecture.
3. Highest math course taken in high school.
 1. Algebra I
 2. Geometry
 3. Algebra II
 4. Trigonometry
 5. Probability
 6. Advanced Math (functions, limits)
 7. Calculus

4. Sex:

1. Male
2. Female

5. College Grades:

1. Hardly ever below B.
2. Mostly B's and C's.
3. Mostly C's.
4. C's and D's or lower.
5. Entering Freshman (no grades yet).

**The vita has been removed from
the scanned document**

A FACTOR-ANALYTIC STUDY OF MATHEMATICS ANXIETY

by

Jeanne Lan Ling

(ABSTRACT)

The purpose of this study was to investigate student attitudes towards mathematics and mathematics anxiety. In the past, mathematics anxiety has been measured by using different instruments and characterized as a unidimensional construct. However, prior studies concerning mathematics anxiety have not established construct validity of the scales used. This study was designed to establish the construct validity of the scales used to measure mathematics anxiety and to investigate the possibility that it may be a multidimensional construct.

A series of self-report questions and survey instruments was administered in 17 freshmen college mathematics classes containing 491 students. Eight instruments were selected, namely: (1) Usefulness of Mathematics, (2) Test Anxiety Inventory, (3) Mathematics Anxiety, (4) Adjective Check List, (5) Short-form Dogmatism, (6) Attitude Toward Success in Mathematics, (7) Effectance Motivation in Mathematics, (8) Confidence in Learning Mathematics.

Factor analysis techniques were used to treat the data: (1) To analyze the scores from the eight tests and reduce the responses to

six principal factors which describe the nature of mathematics anxiety, (2) To determine the strength of the relationships of these attitudes to sex, socioeconomic status, college curriculum, high school mathematics background, college grade point level and achievement in current mathematics courses.

The results suggest that mathematics anxiety is a unidimensional construct related to students' attitude towards mathematics more than to their personality characteristics. A finding contrary to the literature was that females did not suffer mathematics anxiety more than males.

Recommendations arose from consideration of which attitudes in the mathematics anxiety complex were potentially modifiable by educators. It was recommended that schools actively seek to improve these attitudes. It was also recommended that females be encouraged to success in mathematics and that colleges seek to identify and help entering students who exhibit mathematics anxiety.