AN EXPLORATION OF THE FACTORS RELATING TO THE SYSTEM OF MATHEMATICS ANXIETY

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CHAPTER I

INTRODUCTION

Few persons deny the importance of mathematics in the world today. In describing its importance, Sells (1978) uses the term "critical filter" to denote the role mathematics plays in the career choices of students. By this Sells means that a deficiency in mathematics can severely limit educational and occupational planning. Sells conducted a survey of high school graduates entering the University of California at Berkeley. She found that because the graduates had not taken a full complement of college preparatory mathematics courses, 43 percent of the men and 92 percent of the women did not have the mathematics background for a large number of major fields of study. Acording to Sells, these students were limited to career choices in the humanities, social work, elementary education, guidance and counseling, and music. Thus, decisions made at the high school level regarding mathematics affected career options of a large portion of men and women in California. In this sense, mathematics, or the lack of it, truly functioned as a filter for these persons.

If Sells' findings are representative of the general college population, a large proportion of young people often face limited career options by the time they enter college. It thus becomes important to determine why so many students have inadequate mathematics backgrounds. There are a number of possible explanations for this lack of preparedness, such as lack of encouragement on the part of teachers, genetic predispositions, or the perceived dry and uncreative aspects of mathematics, however this study examined another possible explanation for this lack of preparedness: mathematics anxiety.

Outline of the Study

The principle purpose of the study was to determine factors most strongly related to mathematics anxiety. In examining mathematics anxiety, this first chapter includes the following sections: a definition of mathematics anxiety, a presentation of variables relating to it, a discussion of its prevalence and consequences, and the purpose and significance of this study. The chapter concludes with a presentation of the specific hypotheses addressed in the study.

Chapter II develops a definition and theoretical framework for studying mathematics anxiety. With a basic understanding of mathematics anxiety established, the chapter reviews the history of the study of attitudes toward mathematics and then examines those studies relating specifically to mathematics anxiety. Based on this detailed investigation, a clear rationale is established for the inclusion of the variables in this study and for the efficacy of exploring mathematics anxiety.

The third chapter, methodology, includes a description of the population to be studied and the instruments which were used. A statement of the specific methods used in collecting the data and analysis procedures completes the chapter. The fourth chapter contains the results of the analyses performed to test the specific hypotheses and the fifth and final chapter reports the conclusions and recommendations made on the basis of the study.

Overview of Mathematics Anxiety

Definition of Mathematics Anxiety and Related Variables

Mathematics anxiety is a sequence of cognitive, affective, and behavioral responses to a perceived self-esteem threat which occurs as a response to situations involving mathematics. Such situations include taking a mathematics examination, balancing a checkbook, or calculating a problem in a mathematics class. A more complete development of the definition, based upon research regarding anxiety in general as well as mathematics anxiety in particular, is presented in the next chapter. However, from the above brief introduction to the concept, the complex nature of mathematics anxiety is evident from the inclusion in the definition of cognitive, affective, and behavioral aspects. Because of this complexity, mathematics anxiety is best viewed as a system, with all factors interacting to form the whole. Webster's Third New International Dictionary (1981) defines "system" as "a complex unity formed of many often diverse parts subject to a common plan or serving a common purpose;...an aggregation or assemblage of objects joined in regular interaction or interdependence."

There are three important points in this definition as it relates to the system of mathematics anxiety. The first is that it is complex. Mathematics anxiety is complex in nature and it is difficult to explore as a whole. This complexity will be evident after reading Chapter II. The second point is that mathematics anxiety is made up of diverse parts, which are the cognitive, affective, and behavioral aspects of the system. Third, this system is interdependent, meaning that all variables act in concert to form the system. This interdependence will also be supported in Chapter II.

Behavioral aspects of the system of mathematics anxiety include immediate physical responses such as nervous stommach, sweating, muscle contractions, a tightness in chest or throat, heart palpitations, and tension headaches (Byrd, 1982). A more long-term behavioral response is the avoidance of mathematics (Aiken, 1976). Avoidance of mathematics is generally manifested by a person not taking mathematics courses or avoiding activities or degree programs which require mathematics (Byrd, 1982).

Variables in the cognitive area include the following:

1) the lack of confidence in one's ability to perform mathematical tasks (Fennema & Sherman, 1976; Gourgey, 1984);

2) the belief that mathematics is not useful (Byrd, 1982; Fennema & Sherman, 1976);

3) acceptance of misconceptions about mathematics (Gourgey, 1984);

4) the belief that one's parents are not interested in one's mathematics achievement, do not encourage mathematics effort, and do not have confidence in one's mathematical ability (Fennema & Sherman, 1976; Poffenberger & Norton, 1956);

5) belief that one's teachers view one as having poor ability in mathematics, and are thus not encouraging or interested (Poffenberger & Norton, 1959).

In the affective domain are lack of enjoyment in performing mathematical tasks (Fennema & Sherman, 1976; Frary & Ling, 1983), and general and test anxiety (Brush, 1978; Dew, Galassi, & Galassi, 1983). In addition to these variables from the three domains, the organismic variable of gender appears to have some impact upon levels of mathematics anxiety.

A factor not included in the literature on mathematics anxiety is cognitive style, however, it appears that current research allows for a case to be made for linking cognitive style with mathematics anxiety. This theoretical link between mathematics anxiety and cognitive style is developed in Chapter II.

Prevalence of Mathematics Anxiety

Mathematics anxiety appears to be quite prevalent. For instance, Richardson and Suinn (1972) indicated that one third of students requesting behavioral counseling at Colorado State University complained of anxiety related to mathematics. Betz (1978) found that 50 percent of students in the general college population experience mathematics anxiety to some degree. Those students lacking the mathematical background required for college mathematics courses experienced greater amounts of anxiety.

These studies, as well as work by others (eg. Dutton, 1954; Lazarus, 1974), show that a significant portion of students experience some form of mathematics anxiety. Many of these students actively seek counseling to overcome this anxiety. When these findings are coupled with those of Sells (1978) regarding the lack of mathematical preparedness of students entering the University of California, they indicate the need for a thorough understanding of mathematics anxiety in order to allow students to choose careers based upon positive interest and not avoidance of mathematics.

Consequences of Mathematics Anxiety

There are both immediate and long term consequences for persons experiencing mathematics anxiety. In addition to the previously cited narrow choice of academic and career options, these consequences include lower grades and lack of persistence in and enjoyment of mathematics. A number of researchers (Betz, 1978; Frary & Ling, 1983; Seepie & Keeling, 1978) have established a positive relationship between high levels of mathematics anxiety and lower grades in mathematics courses. There is also a relationship between attitudes toward mathematics and persistence in mathematics (Aiken, 1976).

Persons experiencing mathematics anxiety are likely to take the minimum number of mathematics courses possible in high school and college. In the short-term, viewing mathematics anxiety as a system, one sees that anxiety can lead to lowered performance, which induces increased anxiety. This anxiety can influence a person to avoid situations involving mathematics. This lack of attention to mathematics may then lead to reduced performance which can then additionally influences the system. These short-term consequences have far reaching results, such as being "locked out" of a career choice because of inadequate mathematics preparation.

The long-range consequences of mathematics anxiety are those documented by Sells (1978) in her study at the University of California at Berkeley. Students who have avoided mathematics in high school are inadequately prepared for a large number of academic fields. Byrd (1982) documents instances whereby students fail to complete graduate work in non-technical fields due to a statistics requirement in the plan of study.

Thus, the consequences of mathematics anxiety are not limited to getting through, or avoiding, an algebra course in high school. These consequences continue on into college, and the results of choices made there continue long after a student graduates since advancement in a career which includes the performance of mathematical tasks can be impaired.

Overview of the Study

Purpose of the Study

This study examined a number of factors related to mathematics anxiety in beginning college students in order to determine those variables which have the most impact upon the system. Of specific interest are the following 11 variables: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics, 6) gender, 7) perceptions of paternal attitudes toward one as a learner of mathematics, 8) perceptions of maternal attitudes toward one as a learner of mathematics, 9) perceptions of teacher attitudes toward one as a learner of mathematics, 10) number of mathematics courses taken in high school, and 11) cognitive style.

These variables were chosen for one of three reasons. The first is that there was general agreement among researchers studying the variable that it is significantly related to mathematics anxiety. The second reason is that although there is some disagreement as to the significance of the variable, many researchers singled it out for study. The third reason, which applies only to cognitive style, is that while there is no support in the literature for including the variable, there appears to be support for including it in the study. This support will be described in Chapter II.

Significance of the Study

As previously stated, Sells (1978) suggests that by the time students enter college, many have already limited career and educational choices as a result of their lack of adequate mathematical preparation. It is important to understand better the factors relating to decisions regarding mathematics. This study identified from the research literature those factors most strongly associated with mathematics anxiety in college students as well as the relative strength of each variable's contribution to overall levels of anxiety. Consequently, the information obtained from this study assists in identifying persons who are likely to experience higher levels of mathematics anxiety. It also provides clues as to what might be done to ameliorate anxiety prior to entering college in order that high school graduates are not unduly limited in their career choices.

Hypotheses

The following are the specific null hypotheses explored in this study.

Null Hypothesis 1: There are no significant correlations between mathematics anxiety and each of the following variables: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics 6) gender, 7) perceptions of paternal attitudes towards one as a learner of mathematics, 8) perceptions of maternal attitudes towards one as a learner of mathematics, 9) perceptions of teacher attitudes towards one as a learner of mathematics, 10) number of mathmatics courses taken in high school, and 11) cognitive style.

Null Hypothesis 2: There are no gender differences in reported levels of mathematics anxiety when controlling for the number of mathematics courses taken in high school.

Null Hypothesis 3: The following variables do not enter a multiple regression analysis as significant predictors of mathematics anxiety: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics 6) gender, 7) perceptions of paternal attitudes toward one as a learner of mathematics, 8) perceptions of maternal attitudes toward one as a learner of mathematics, 9) perceptions of teacher attitudes towards one as a learner of mathematics, 10) number of mathematics courses taken in high school, and 11) cognitive style.

Chapter Summary

Learning is a complex process influenced by many factors. The difficulty in learning mathematics seems to be compounded by the emotions which the subject elicits. One rarely, if ever, hears of "English anxiety" debilitating a student, or how just the mention of the word "civics" makes one break out in a cold sweat. Such comments are not unusual, however, when referring to mathematics.

The problem is compounded when viewing the research regarding students' lack of preparedness in this area and the persons who do not complete degree programs because of the mathematics requirements. For these reasons the examination of mathematics anxiety is a timely subject.

This study presents a view of mathematics anxiety as a system made up of a number of cognitive, afffective, behavioral, and demographic factors. It explores those variables which appear to be most closely related to mathematics anxiety. The following chapter reviews both the historical and current literature regarding mathematics anxiety and establishes a clear theoretical reationale for conducting this study.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The previous chapter introduced the construct of mathematics anxiety as a complex system comprised of a number of behavioral, affective, cognitive, and organismic factors. Specifically, this system of anxiety is hypothesized to be comprised of the following variables: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics, 6) gender, 7) perceptions of paternal attitudes toward one as a learner of mathematics, 8) perceptions of maternal attitudes toward one as a learner of mathematics, 9) perceptions of teacher attitudes toward one as a learner of mathematics, 10) number of mathematics courses taken in high school, and 11) cognitive style. This chapter examines these variables within the system of mathematics anxiety from both a theoretical and research perspective.

This chapter has five main parts. First, a definition of mathematics anxiety is developed using several definitions of the construct, based also on a brief look at research in the area of anxiety. The second section examines the history of the study of attitudes toward mathematics. Studies from three broad categories within the literature were reviewed: opinion articles, observational studies, and correlational studies. The third section of the chapter looks at results of studies dealing specifically with mathematics anxiety. The studies are examined as they relate to each of the variables incorporated with the present study.

Following a presentation of those variables found to be related to mathematics anxiety, the chapter's fourth section presents a case for including cognitive style as a part of the system of mathematics anxiety. The fifth and final portion of the chapter will summarize the material presented and provide the rationale for the present study.

Defining Mathematics Anxiety

Overview

Among the most active investigators of attitudes toward mathematics are Aiken (1963, 1970, 1974, 1976), Richardson, and Suinn (1972), Fennema and Sherman (1976). The first part of this section will examine the early definitions of mathematics anxiety proposed by these researchers. Second will be a brief review of general anxiety as described primarily by Aiken (1962), Spielberger (1972a, 1972b), and others.

Aiken's work is of particulat interest because his research investigates both general anxiety and attitudes toward mathematics. Spielberger is a recognized authority in the field of anxiety research, and his work has been related by researchers to mathematics anxiety (e.g. Byrd, 1982) The third part of this section presents the definition of mathematics anxiety used as a theoretical basis for this study.

Early Definitions of Mathematics Anxiety

Most researchers examining mathematics anxiety have been primarily concerned with the measurement of the construct rather than establishing a clear conceptual base for the construct on which to base their examinations. The definitions proposed by Aiken and Dreger (1961), Richardson and Suinn (1972), and Fennema and Sherman (1976) reflect this deficit. Aiken and Dreger (1961) define mathematics anxiety as "pronounced fears in the presence of arithmetic and mathematics" (p. 19). Richardson and Suinn (1972) provide a more comprehensive definition when they say that it 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). Furthermore, Fennema and Sherman (1976) emphasize that mathematics anxiety is manifested in both affective and physical ways by stating that it involves "feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics" (p. 4).

While these three definitions provide adequate descriptions of mathematics anxiety for the purposes of general discussion, they are not sufficient for this study because they utilize the words "anxiety" and "fear" in defining a form of anxiety. This circularity prevents a true understanding of the construct and demonstrates the above-stated lack of adequate theoretical groundwork. Many studies describe the construct and variables associated with it, but do not examine its underlying structure. A seemingly better way to define mathematics anxiety is to look first at the underlying construct of anxiety. Consequently, in order to address this deficiency, this review of the literature looks briefly at research in anxiety before formulating a definition of mathematics anxiety.

Anxiety

Overview of Anxiety

Researchers generally agree that there is much similarity between fear and anxiety. For example, Izard (1972) presents fear as one of nine fundamental emotions. Fear is an avoidance motive which, when highly aroused, leads to flight or other physical action (Spielberger, 1972a). While some researchers (Izard, 1972; Tomkin, 1972) make no real distinction between fear and anxiety, others (Lazarus & Averill, 1972) distinguish fear from anxiety by the presence of cognitive mediators. Thus, fear is primarily a physiological reaction, while anxiety is more cognitive. Byrd (1982) agrees with the latter theorists; she distinguishes fear from anxiety by stating that fear is to physical threats as anxiety is to psychological threats. The approach taken in this study is that of Lazarus and Averill (1972), and Byrd (1982): anxiety is similar to fear, but it is psychological in nature. Byrd extends the discussion of anxiety and takes an existential viewpoint in stating that the greatest psychological threat is a threat to self-esteem. This hypothesis as it relates to mathematics anxiety will be explored further in this chapter.

Types of Anxiety

Just as fear and anxiety are similar, but separate constructs, so too are there similar but distinguishable forms of anxiety. Basically there are two forms of anxiety; this distinction between the two types of anxiety will be useful in the understanding of mathematics anxiety.

Aiken (1962) calls the two types of anxiety "general" and "situational" anxiety while Spielberger's (1972a) commonly used labels refer to general anxiety as "A-trait" and situational anxiety as "A-state." A-trait is defined as "... relatively stable individual differences in anxiety proneness, that is, to differences in the disposition to perceive a wide range of stimulus situations as dangerous or threatening and in the tendency to respond to such threats with A-state reactions" (1972a, p. 39). A-state is defined as "... a transitory emotional state or condition of the human organism that varies in intensity and fluctuates over time" which is "...characterized by subjective, consciously perceived feelings of tension and apprehension, and activation of the autonomic nervous system" (Spielberger, 1972a, p. 39).

The difference between these two types of anxiety are more in degree than kind. Aiken states that "the difference between 'general anxiety' and 'situational anxiety,' rather, is in the number of stimulus situations which elicit anxiety reactions" (1962, p. 108). Someone who experiences higher levels of trait anxiety will experience state anxiety in response to more situations than will someone with lower levels of trait anxiety.

The specific response to anxiety-provoking situations Spielberger calls anxiety-as-process, or A-state reactions, which he defines as "the sequence of cognitive, affective, and behavioral responses that occur as a reaction to some form of stress" (Spielberger, 1972b, p. 484).

Conclusions Regarding General Anxiety

Based on the above-cited research, five conclusions can be drawn regarding anxiety. First, anxiety appears to be similar to fear. Second, cognitive mediation separates anxiety from fear. Third, anxiety contains physiological, cognitive, and affective componants. Fourth, anxiety arises as a response to perceived psychological threats, the greatest of which are threats to self-esteem. Fifth, these anxious responses may be made to specific situations or they may generalize to a wide variety of stimuli.

As mathematics anxiety is a specialized form of general anxiety, it is useful, if not essential, when examining mathematics anxiety, to keep these five points regarding general anxiety in mind.

Final Definition of Mathematics Anxiety.

In her exploration of mathematics anxiety, Byrd (1982) applied the precepts stated above, using Spielberger's view of anxiety, in defining mathematics anxiety. She calls it "a collection of A-state reactions to situations involving mathematics induced by perceptions of threat to self-esteem" (p. 11). A failure at a mathematical task may challenge one's perception of self, and one may experience feelings of self-doubt, or anxiety. Mathematics anxiety, then, is a perceived threat to self-esteem brought about in situations involving mathematics. Specifically, the definition of mathematics anxiety used in this study is that it is a system of cognitive, affective, and behavioral responses to a perceived threat to self-esteem which occurs as a response to situations involving mathematics.

Review of Attitudes Toward Mathematics

Introduction

The study of mathematics anxiety as a separate construct began in the 1950's; however, most of the empirical studies conducted prior to the 1970's were concerned with overall attitudes toward mathematics, and did not single out anxiety for study. The difference between the research conducted into attitudes regarding mathematics and that conducted into mathematics anxiety appears to be primarily a difference of semantics. The scales measuring attitudes and anxiety contain similar items and researchers in the two areas draw many of the same conclusions. For example, the attitude scale developed by Aiken and Dreger (1961) contained the item "when I hear the word math, I have a feeling of dislike." In the Mathematics Anxiety Rating Scale (Suinn, Edie, Nicoletti, & Spinelli, 1972) respondents are asked to indicate levels of fright in response to statements such as "walking on campus and thinking about a mathematics course." Dutton's (1954) attitude scale contained the item "I don't feel sure of myself in mathematics," and the Mathematics Anxiety Scale contains the item "mathematics makes me feel uneasy and confused."

It may be useful to utilize McAuliffe, Regina, and Trueblood's (1986) perspective that attitudes toward mathematics are concerned primarily with feelings about the subject and mathematics anxiety focuses on the situational aspects of doing mathematics. It may also be that greater understanding of general anxiety led to a more specific definition of mathematics anxiety. Consequently, this study includes the distinction between the two concepts which is usually observed in the literature.

The early literature may be divided into three primary categories. The first consists of opinion articles concerned with emotional blocks to the learning of mathematics. These authors did not conduct experiments or studies, but drew their conclusions based upon their own observations and experiences. The second category is comprised of those studies which report attitudes held by students toward mathematics. These researchers make no real attempt to explain or make predictions based on their results, but simply report the attitudes held by students. The third group is made up of empirical studies relating to attitudes toward mathematics. The authors of these studies use their results to describe what factors tend to be related to what attitudes.

This section of the chapter will discuss findings from each of these three groups before continuing with an examination of the literature concerned specifically with mathematics anxiety.

Opinion Articles

During the early 1950s, there was growing concern about the decreasing number of students who were choosing to study mathematics (Tulock, 1957). The issues as expressed by Tulock (1957) were twofold. First, mathematics is necessary in all aspects of life and in many educational programs. Second, there was the political "cold war" between the United States and the Soviet Union and the necessity for establishing and maintaining technological superiority over the communist nations. Mathematics anxiety first became a concern as a result of extensive examinations into the study of mathematics.

Gough (1954) is credited with being the first to conceptualize anxiety regarding mathematics (Aiken, 1971), labeling the phenomena "mathemaphobia." A mathematics teacher for 25 years, Gough stated that mathemaphobia was a major cause of failure in mathematics. She cited four major causes of mathemaphobia. The first cause was negative experiences in mathematics. Many students who have anxiety regarding mathematics remember specific incidents which marked the beginning of their anxiety toward the subject. The second cause of mathemaphobia was when important mathematical concepts were missed and never made up. This missing might be the result of an extended illness or could simply be that the student did not understand a concept and thus was unable to comprehend other concepts which built upon the earlier one. While many subjects are cumulative, Gough believes that mathematics is especially so. Related to this second cause is the third: fear of failure.

Students who are at all uncertain about their mathematical abilities express anxiety and concern regarding their performance. The fourth and final cause of mathemaphobia postulated by Gough is the belief that one must have a "mathematical mind" in order to do well, and those who do not have such a mind cannot effectively learn mathematics.

Tulock (1957) viewed the fear of failure as the primary emotional block to the learning of mathematics. She states ... "pupils who constantly fail mathematics have deflated egos and tend to develop attitudes of dislike and hostility toward mathematics. They do not willingly enroll in algebra classes because they are afraid - it represents a threat" (p.572). Tulock agrees with Gough (1954) that persons experiencing emotional blocks to mathematics believe that they are not capable of learning mathematics.

Collier (1959) did not confine himself to attitudes toward mathematics in his article, but addressed all aspects of why persons fail at mathematics. However, it is significant that in his introduction Collier focuses on affective aspects of failure by discussing the many people who "feel incompetent and express dislike, fear, and, yes, even hatred toward the subject" (p. 262). In Collier's opinion, the root of blocks to mathematics lie in an inadequate foundation in the subject. He lists eight reasons for this lack of understanding. Six of the reasons relate directly to the manner in which mathematics is taught, and the other two are fear and dislike of mathematics, and the bad reputation of mathematics. This bad reputation is passed on by older students as well as parents. It seems likely that the bad reputation might relate directly to the fear and dislike of mathematics. Collier stresses that these eight blocks do not work independently, but function together to establish blocks to the learning of mathematics.

The final opinion article to be considered is that of Lazarus (1974). Although this work is more recent than the others considered in this section, it is appropriate here because of its nonempirical nature. Lazarus stated that objective criteria for the detection of what he terms "mathophobia" are not available but that one experiences mathophobia if a person:

> strongly dislikes mathematics in school; goes out of his way in education and career to avoid having to 'do' mathematics; if he regards mathematics as a sort of cabalistic mystery or lodge secret beyond his access and comprehension; or, of course, if he speaks openly of his aversion toward, and difficulty with mathematics (p.17).

By this criteria, Lazarus would agree that a majority of persons in this country experience mathopobia.

Lazarus has two main concerns regarding mathophobia. The first is the large number of persons who experience mathophobia. The second is the apparant lack of concern which this causes. It appears perfectly acceptable for persons to admit that they cannot and will not perform mathematical tasks. Children who cannot do well in mathe-ematics classes are often excused, either overtly or co-overtly, by parents and teachers because they themselves are not comfortable with mathematics.

Lazarus (1974) cites three primary causes for mathophobia. First is the cumulative nature of mathematics. The second and third causes are the attitudes of parents and teachers, respectively, toward the subject. Lazarus stated that many public school teachers experience mathophobia, especially relating to higher levels of mathematics. Elementary school teachers may be anxious about algebra, and algebra teachers may not be comfortable with calculus. The results are that these attitudes are transmitted to the students at home and at school.

Summary of Opinion Articles

Certain common characteristics may be noted in the opinions espoused by these writers. The first is the cumulative nature of mathematics and how failure to keep up with material will almost guarantee anxiety in later work. Another common characteristic is the belief that there is a mathematical mind, which some persons have and others do not. The fear of failure is the final opinion shared by the authors. Of interest, also, are the concerns expressed by Collier (1959) and Lazarus (1974) regarding the impact on younger students of parents and others who may be anxious about mathematics. Lazarus placed special emphasis on this impact.

These opinion articles lend support to the idea that mathematics anxiety is a system contributed to by a number of causes. Some ideas, such as fear of failure, are affective in nature; others, such as belief in a mathematical mind and not understanding concepts are cognitive in nature. While these observations lend support to the viewpoint of this study, empirical support is needed. The following section begins the review of empirical studies conducted into attitudes toward mathematics.

Attitude Surveys

The researchers reviewed in this section completed empirical studies on attitudes toward mathematics, but made no real attempt to discover causes or relationships among the attitudes. Foremost among these researchers is Dutton, who developed scales to measure attitudes in prospective teachers (Dutton, 1954) and elementary school students (Dutton & Blum, 1968).

Recognizing the important part attitudes played in learning, Dutton (1954) developed a 22-item scale to measure attitudes toward mathematics. He administered the scale to 289 students who were preparing for careers in teaching. The negatively-worded statements chosen most frequently by all respondants included "I don't feel sure of myself in mathematics," "I am afraid of doing word problems," "I have always been afraid of arithmetic," and "I avoid arithmetic because I am not very good at figures."

Those positively-worded statements chosen most often included "I enjoy doing problems when I know how to work them," "Sometimes I enjoy the challenge presented by an arithmetic problem," and "Arithmetic is as important as any other subject." It is interesting to note how the first statement is mediated by the phrase, "when I know how to work them," and the second question includes the conditional word "sometimes." When asked to provide causes for any dislike of mathematics, the reasons given most often were lack of understanding, poor marks, difficulty in working problems, poor teachers, and insecurity.

Dutton and Blum (1968) revised Dutton's scale and enlarged it to include items referencing new mathematics before administering it to a stratified random sample of 346 sixth, seventh, and eighth graders from one community. They found that all students agreed that mathematics should be avoided whenever possible; word problems were frustrating; there were too many rules to learn and too many opportunities to make mistakes in mathematics; and that mathematics, especially the new mathematics, is a waste of time.

Expanding the generalizability of Dutton's work, Fendon (1958) used a modified version of Dutton's original scale to measure the attitudes of 32 third graders from an intact class. His findings were similar to those reported by Dutton (1954). The negatively-worded statements chosen most frequently related to dislike and fear of the subject, avoidance of mathematics due to lack of confidence, and failure to see the use in studying mathematics. The positively-worded items chosen most frequently related to enjoyment in successfully working problems, the desire to think about and perform mathematical tasks, and the attraction of mathematics as an academic subject.

Fendon concluded that definite attitudes toward mathematics were in place by the third grade and that some of these were positive and some were negative. He also noted that "there is a general feeling that various aspects of arithmetic are enjoyable and necessary, but not always meaningfully significant" (p. 310). The similarity of Fendon's results with third graders to those found by Dutton (1954) in older students seems to indicate that similar attitudes toward mathematics are held by most students. These findings are important as they show that attempts to instill positive attitudes toward mathematics in students must be undertaken early in order not to become efforts to change already established attitudes.

Summmary of Attitude Surveys

There was general agreement in these opinion articles on three primary factors afffecting negative attitudes toward mathematics: 1) the cumulative nature of mathematics, 2) belief in a mathematical mind, and 3) fear of failure. Also of importance were the attitudes of parents and teachers. Respondents in these studies reported by Dutton (1954), Dutton and Blum (1968), and Fendon (1958) provide validation for the fear of failure hypothesis in that students of all ages reported uncertainty and anxiety about performing mathematical tasks. Although there is no direct evidence regarding belief in the mathematical mind and the cumulative nature of mathematics, the number of students agreeing with the statement "I have always been afraid of arithmetic" and concerns about the lack of understanding and difficulty in working problems may be seen as indirect support.

The work presented in this section is useful, but what is lacking is an understanding of why certain persons hold certain attitudes. The following section reviews studies which focused on correlations between respondent characteristics and attitudes toward mathematics.

Empirical Studies

Introduction

A problem with the empirical studies regarding attitudes toward mathematics reviewed below is their tendency to focus on only one aspect of attitudes to the exclusion of other areas which may also have an impact on attitudes. Studies can be divided into two main catagories: those investigating social influences (Poffenberger & Norton, 1956, 1959); and those examining gender and personality correlates with attitudes (Aiken, 1963; Aiken & Dreger, 1961; Behr, 1973). Interestingly, the common areas of study among these studies yielded conflicting results.

Several specific studies will be reviewed in this section. Overall, however, the three main conclusions from the studies are first, parents, especially fathers, and teachers exert a great deal of influence upon attitudes of students. Second, women hold less favorable attitudes toward mathematics than do men, and these attitudes have greater impact on achievement for women than for men. The third conclusion is that there is a tendency for persons with less positive attitudes toward mathematics to be more socially and intellectually immature than persons holding more positive attitudes.

Social Influences on Attitudes

Poffenberger and Norton (1959) utilized the information gained from a pilot study (1956) to develop an instrument which they administered to 390 college freshmen. The survey included items on father and mother attitudes toward mathematics, father and mother expectations in general school work and mathematics, attitudes toward school in general, feelings about specific mathematics courses, and attitudes toward mathematics teachers. The authors also requested information on gender, grades, size of school and other demographic variables. For the data analysis the researchers used only the responses from those students reporting positive or negative attitudes toward mathematics. To control for ability, only three percent of the final sample had less than a "B" grade average in high school.

Students who perceived that their fathers held positive attitudes toward mathematics, who received encouragement from both parents to do well, and from whom both parents expected good grades in mathematics, had the most positive attitudes toward mathematics. These attitudes were significantly more positive than the attitudes of students who perceived their fathers as holding more negative attitudes, who felt that their parents did not have high expectations, or who had parents who provided little encouragement in mathematics performance. The perceived attitudes of mothers toward mathematics did not differentiate between the groups.

The role teachers played in developing attitudes toward mathematics was not as clear because students experienced difficulty recalling earlier teachers. Students from the less positive group consistently reported having poorer mathematics teachers. However, conclusions need to be drawn carefully, as the authors speculated that dislike for the subject may have influenced opinions of the teacher. Students in the less positive group expressed more dislike for the subject than dislike of teachers. Factors not differentiating the groups with less and more positive attitudes included gender, size of high school, closeness with parents, childhood happiness, present life adjustment, ability to get along with others, and overall high school grades.

Poffenberger and Norton (1959) concluded their study by stating that "the present lack of interest in mathematics is largely a cultural phenomena pervading not only the educational system of the country, but also the family as an institution that conditions the attitudes of children" (p. 175). Poffenberger and Norton argue that attitudes toward mathematics are cumulative in nature, having their beginnings before schooling begins, and thereafter being reinforced by teachers and parents.

While Poffenberger and Norton adequately examined the influence of parental and teacher inpact on attitudes toward mathematics, their conclusions are not definitive. In both their pilot and main study they focused almost exclusively on familial and school influences. They did not report information concerning the reliability or validity of their instrument except to state that the question as to the validity of the answers is open due to the nature of all attitude inventories.

Personality and Gender Influences on Attitudes

Three of the remaining four studies in this section of the chapter focus on the effect of personality factors and gender on attitudes toward mathematics. The fourth study examined the relationships among gender, attitudes, achievement, and aptitude in mathematics. Each of these studies utilized established measures of personality constructs in addition to a mathematics attitude scale developed by Aiken and Dreger (1961).

The 1961 study conducted by Aiken and Dreger, was designed to address the following hypotheses:

1) mathematics attitude scores make a significant concontribution to the prediction of final grades in a mathematics course,

2) mathematics attitude scores predict gains in scores on a mathematics achievement test,

3) mathematics attitudes are unrelated to general personality variables,

4) mathematics attitudes are positively related with numerical ability,

5) mathematics attitudes are positively related with ratings of mathematics teachers,

6) mathematics attitudes are positively related with reports of parental encouragement,

7) mathematics attitudes are unrelated to parental encouragement in academic subjects in general,

8) mathematics attitudes are positively correlated with reports of parental attitudes toward mathematics, and

9) negative attitudes towards mathematics are correlated with negative experiences in mathematics.

The subjects were 127 freshmen enrolled in general mathematics courses at a southeastern college in the fall semester.

The results from the survey indicated that mathematics attitudes were related to all subjects' perceptions of teachers, to achievement in mathematics courses only for women, and that personality variables, parental attitudes, and parental encouragement were not related to attitudes towards mathematics.

Numerical reasoning ability was the best predictor for mathematics attitudes and persons with positive attitudes toward mathematics made higher gains on a mathematics achievement test. Traumatic experiences in mathematics did not appear to contribute to negative attitudes toward mathematics.

It is interesting that these results are contrary to those of Poffenberger and Norton (1959), who found that the family was a significant contributor to attitudes toward mathematics. These differences in results may be due to the instruments used. Poffenberger and Norton used a scale designed to measure familial impact on attitudes while Aiken and Dreger (1961) modified the Intensive Personal Data Sheet to include questions regarding father and mother encouragement and attitudes regarding mathematics. This raises some question as to the validity of the measures, which Aiken and Dreger also noted. It does not seem unreasonable to accept the findings of Poffenberger and Norton regarding parental influence as the social influences on attitudes were their primary focus and Aiken and Dreger had minimal measures for these social influences.

As it appeared that nonintellectual factors were more important in the development of female rather than male students' attitudes toward mathematics, Aiken (1963) limited a follow-up study to female subjects. In this project, 160 female college sophomores were administered a revision of the Mathematics Attitude Scale, the California Psychological Inventory (CPI), the Sixteen Personality Factor Questionnaire (16 PFQ), and the Study of Values (SV). In addition to these instruments, the womens' scores on the Scholastic Aptitude Test (SAT) were used as a measure of intellectual ability. After partitioning out mathematical ability as measured by the SAT-mathematics portion, it appeared that students with more positive attitudes toward mathematics "tend(ed) to be more socially and intellectually mature, more self-controlled, and place(ed) more value on theoretical matters than low scorers on the scale" (p. 479).

A final study by Aiken to be considered here is one reported in 1974. One hundred eleven male and 128 female college sophomores completed the 10 Adjective Checklist, the SAT-Quantitative portion, and Aiken's Mathematics Attitude Scale. The results indicated that positive attitudes toward mathematics were correlated with self-control; personal adjustment; and need for achievement, endurance, and order. Negative attitudes toward mathematics were related with emotional lability and need for aggression.

Behr (1973) utilized Aiken's scale in measuring the relationships among achievement, aptitude, and attitudes in mathematics, taking the gender of the individual into account. His subjects were 173 female and 150 male freshmen studying the liberal arts in New York. People included in the study had completed intermediate algebra and had overall high school averages between 75 and 85. In addition to providing information regarding their averages in high school mathematics courses, respondents completed the Aiken Inventory and the SAT-Quantitative section.

Behr found that the male students in this liberal arts program had higher aptitude and greater interest in mathematics than the female students, however, there were no differences in achievement. Also, the relationships among aptitude, achievement, and attitudes were stronger for women than men. This suggests that given knowledge of attitudes and aptitude, the mathematics grades of women studying in this liberal arts program could be predicted with more accuracy than the mathematics grades of men.

Summary of Empirical Studies

From the above studies there appears a picture of persons who have negative attitudes toward mathematics, and some indications of how these attitudes developed. Women seem more likely to hold more negative attitudes toward mathematics, and these attitudes have greater effect on their achievement than do the attitudes of males. Women with less positive attitudes tend to be less socially and intellectually mature, less self-controlled, and place less value on theoretical matters. They generally do not perform as well in mathematics courses as do persons with more favorable attitudes toward the subject. It is questionable whether these charateristics may be applied to men with less favorable attitudes; however, there is some support for the idea that all persons who hold negative attitudes toward mathematics are not as well adjusted as those persons holding more positive attitudes (Aiken, 1974).

Persons with negative attitudes toward mathematics also tend to achieve smaller gains on mathematics achievement tests and demonstrate poorer numerical reasoning skills than persons holding more positive attitudes. Persons holding these negative attitudes express uncertainty and fear regarding mathematical tasks, and may believe that they are not able to learn mathematics. Persons with less favorable attitudes toward mathematics have fathers who hold similar attitudes, and have both fathers and mothers who do not expect or encourage high achievement in mathematics. High school mathematics teachers of these students generally did not demonstrate enthusiasism for or expertise in their subject.

Conclusions Regarding Attitudes Toward Mathematics

While there is a lack of shared focus in the historical literature discussed above, there is agreement on a number of facts among the three research areas reviewed. The writers of opinion articles on attitudes toward mathematics agreed that a fear of failure characterized those persons holding negative attitudes. The work of Dutton (1954) and Fendon (1958) support this as students in their studies who held less positive attitudes reported more feelings of insecurity, fear, and lack of confidence in the subject.

In comparing the findings from these empirical studies with the propositions expressed by the writers of the opinion articles, there was not support for the concept of a "mathematical mind," as the issue was not addressed in the studies reviewed. Neither was there direct support for belief that the cumulative nature of mathematics contributed to negative attitudes toward mathematics. However, statements from Dutton and Blum's (1968) participants that there were too many rules to follow and too many chances for mistakes in mathematics could be taken as support for the idea that to effectively grasp mathematical concepts, one must keep up with each day's work.

Regarding Lazarus' (1974) opinion as to the importance of parents and teachers in the formation of attitudes there is general agreement. Poffenberger and Norton's (1956, 1959) findings support this conclusion. The disparity between their findings and those of Aiken and Dreger (1961) may be due to the latter researchers' instruments. There is agreement among all those who addressed the issue that teachers who do not appear to care for students or who express indifference or anxiety towards mathematics negatively affect their students' attitudes.

In addition to these findings, it appears that women hold less favorable attitudes toward mathematics and these attitudes affect their performance more than do the attitudes held by men. Persons with more negative attitudes may have less healthy personalities, and they demonstrate less numerical ability.

Review of Recent Research in Mathematics Anxiety

Introduction

This section of the review addresses current research in the area of mathematics anxiety. As stated in the last section, the primary difference between the study of attitudes toward mathematics and mathematics anxiety may be one of semantics. Another important difference is the instrumentation used in the investigations. In his two reviews of the literature regarding attitudes toward mathematics, Aiken (1970, 1976), expressed the need for valid and reliable instruments to measure mathematics attitudes. In the last of the reviews, he expressed hope that the newly developed Mathematics Anxiety Rating Scale (MARS) (Suinn, Edie, Nicoletti, & Spinelli, 1971) would prove to be such an instrument. It now appears that the MARS, as well as the Mathematics Anxiety Scale (MAS) (Fennema & Sherman, 1976), have withstood the tests of analysis and useage. The use of reliable and valid measures of mathematics anxiety may be said to separate the reports of attitudes reviewed in the previous section of this chapter and those revived in this section.

The present section of this chapter is organized around the variables found to be associated with mathematics anxiety. The decision on which variables to include was based on its repeated occurrence in the literature. While there is total agreement among researchers regarding some variables, such as test anxiety and confidence in one's mathematical ability, there are conflicting reports regarding other variables.

The variables will be examined in the following order: 1) trait, and test anxiety; 2) confidence in learning mathematics; 3) perceived usefulness of mathematics; 4) acceptance of misconceptions about mathematics; 5) enjoyment of mathematics; 6) perceptions of father, mother, and teacher attitudes toward one as a learner of mathematics; 7) mathematical preparedness; 8) gender; and 9) cognitive style. Under the heading of each variable, selected research will be reviewed. As some studies address a number of variables, the first time an article is referenced, it will be discussed in full. If material from the article is relevant under another heading, only the pertinant material will be repeated.

This investigation of variables associated with mathematics anxiety begins by examining the relationships among mathematics anxiety and other types of anxiety. The reason for beginning here is that mathematics anxiety is a specific form of anxiety and shares features in common with types of general anxiety.

Mathematics Anxiety and State/ Trait Anxiety

Introduction

As may be recalled from the earlier treatment of anxiety, general anxiety may be catagorized as state or trait. These are similar in form and expression, differing in the levels by which they are experienced. Trait anxiety refers to the tendency for a person to experience state anxiety.

Byrd (1982) hypothesized a link between mathematics anxiety and state anxiety, and Morris, Kellaway, and Smith (1978) refer to mathematics anxiety as a "situation specific trait anxiety" (p. 593). Recent authors (Brush, 1978; Resnick, Viehe, & Segal, 1982) have hypothesized that test anxiety is not only a fear of testing, but also fear of having one's work evaluated in any way. This section presents findings of studies exammining the relationship among mathematics anxiety with measures of state, trait, and test anxiety.

State/Trait Anxiety

Two studies have empirically investigated the link between mathematics anxiety and measures of gemeral anxiety (Betz, 1978; McAuliffe, Regina, & Trueblood, 1986). These authors agree that while there is a relationship between mathematics anxiety and more general types of anxiety, mathematics anxiety cannot be explained solely in light of the other constructs. These researchers examined the relationship between mathematics anxiety and general anxiety by means of the Stait-Trait Anxiety Inventory (STAI) developed by Spielberger, Gorsuch, and Lusbene (1970).

Betz administered a revised version of the Mathematics Anxiety Scale (MAS), the A-Trait scale of the STAI, the Test Anxiety Inventory (TAI) developed by Spielberger (1977), and the mathematics and verbal subscales of the American College Test (ACT) to students from the Ohio State University. The students were enrolled in either the most basic mathematics course offered, a more advanced mathematics course, or an introductory psychology course. Betz was interested in examining the relationships among the variables mathematics anxiety, mathematics ability, general anxiety, and test anxiety; estimating the prevalence and intensity of mathematics anxiety in college students; and determining if levels of mathematics anxiety differ according to sex, age, and levels of high school mathematics.

The results indicated small, but significant relationships between mathematics anxiety, trait anxiety, and test anxiety. McAuliffe, Regina, and Trueblood (1986) found similar correlations between the STAI and TAI, and the MARS. A deficiency in this analysis is the use of simple correlation procedures. A multiple regression analysis would have been helpful to examine the variance shared by the variables.

Ability, as measured by the mathematics subscale of the ACT, was moderately, but significantly related to mathematics anxiety, especially for the students enrolled in the higher level mathematics course. Betz also found significant correlations between ability and mathematics anxiety in females in the psychology course and in males in the basic mathematics course. She found no relationship between verbal ability and mathematics anxiety in any of the groups. Analysis of variance computed by types of course and gender indicate that students in basic mathematics were significantly more anxious than students in either of the other courses. Women in the psychology and basic mathematics courses reported higher levels of mathematics anxiety than men in those courses. Women in the more advanced mathematics course did not report significantly different levels of anxiety than did the men. Age related significantly to higher levels of mathematics anxiety for women, with older women reporting greater levels of anxiety. For both sexes, levels of mathematics anxiety were higher for students who had taken fewer mathematics courses. It may be that the significant difference in levels of anxiety reported by persons in the different mathematics courses are due to the mathematical prerequisites for the more advanced course.

To summarize, several studies found small but significant relationships among mathematics anxiety, trait anxiety, and test anxiety. Also of interest is the apparant relationship between mathematics preparation and mathematics anxiety. This relationship between number of mathematics courses taken and mathematics anxiety may provide an explanation for differences in levels of mathematics anxety reported by men and women. Mathematics has been viewed as a male domain (Fennema & Sherman, 1976), and girls have traditionally not been encouraged to pursue more than basic mathematics courses. Evidence that this is changing may be seen in the significantly higher levels of mathematics anxiety in older womwn, but not older men. This line of reasoning will be pursued further in the section relating to gender.

Test Anxiety

Much work has been done on the relationship between mathematics anxiety and test anxiety. The most widely used measure of the latter is Spielberger's Test Anxiety Inventory (TAI) (1980). Studies previously reported by Betz (1978), McAuliffe, Regina, and Trueblood (1986), as well as a number of other studies, found significant correlations between mathematics anxiety and test anxiety (Brush, 1978; Hendel, 1980; Rounds & Hendel, 1980; Dew, Galassi, & Galassi, 1983).

Brush (1978) explored the relationship among scores on the MARS and the following variables: test anxiety; level of participation in mathematics (field of study, amount of high school mathematics, enrollment in calculus); gender; grades in high school mathematics courses; amd attitudes toward the subject. Brush's study consisted of two samples of 109 and 80 upperclassmen at a private coeducational university. Each sample was made up of approximately equal numbers of majors in the humanities, social sciences, and physical sciences and approximately equal numbers of females and males from each area. The first sample answered questions regarding amount, success in, and attitudes towards mathematical training and the second took the Suinn Test Anxiety Behavior Scale (STABS) (19??). Both samples took the MARS.

The results showed significant differences in levels of mathematics anxiety between those majoring in the physical sciences and those majoring in the social sciences and the humanities. There were no significant differences in levels of mathematics anxiety between social science and humanity majors. In the second sample, significant differences in mathematics anxiety were found between physical science and social science majors and humanity majors. There were no significant differences in levels of mathematics anxiety between physical science and social science majors.

There were significant gender differences in the first sample on total MARS scores. There were no significant gender differences in the second sample. There were no gender differences found most likely because in the second sample there were no differences in mathematical background between the males and females. Higher scores on the MARS were related with more negative attitudes towards mathematics and more anxious students reported receiving significantly lower course grades.

Scores on the MARS were significantly correlated with scores on the STABS, however, there were no differences across gender or field of study. Brush (9178) found that all students in the samples experienced similar levels of test anxiety but experienced dissimilar levels of mathematics anxiety.

In conclusion, Brush found that although there were gender differences between men and women in some groups, these differences could be explained by mathematical preparedness. This conclusion coincides with the finding of Betz (1978). Also of interest is Brush's conclusion that while mathematics anxiety is related to test anxiety, it cannot be fully explained as a form of test anxiety.

Dew, Galassi, and Galassi (1983) conducted a study involving 769 first and second year undergraduates in North Carolina which examined the reliability of the MARS, MAS and Sandman's Anxiety Towards Mathematics Scale (ATMS), and explored the relationship of these measures to each other. Dew, et al. also examined the degree of mathematics anxiety experienced by men and women and the relationship of mathematics anxiety to the TAI.

The three measures of mathematics anxiety were all moderately, but significantly correlated with each other. All of the correlations among the measures of mathematics anxiety were higher than the correlations among these scales and the TAI. The TAI achieved correlations of .57, -.52, and .44 with the MARS, MAS, and ATMS, respectively. Gender differences were explored by means of analysis of variance. There were significant gender differences on both the MARS and the MAS, with women reporting more anxiety than men.

Hendel (1980) found that only self-estimated mathematics ability and test anxiety made meaningful contributions to mathematics anxiety in a multiple regression analysis. Variables included in the study contributing less than 10 percent of the variance in mathematics anxiety were the Fear of Negative Evaluation Scale, the Facilitating and Debilitating Anxiety Scales, a mathematics achievement test, and the personal variables of semesters of high school mathematics, and years elapsed since formal mathematics instruction.

Summary of Findings Regarding Other Forms of Anxiety

In conclusion, mathematics anxiety is significantly correlated with test, trait, and state anxiety, with the greatest amount of variance accounted for by test anxiety. Despite the strong correlations between measures of mathematics anxiety and measures of test anxiety, there is evidence that the evaluation of anxiety related to mathematics anxiety is different than that measured by test anxiety scales. McAliffe, Regina, and Trueblood (1986) state that the evaluation factor in the MARS is comprised of test taking, problem sloving, course related elements, and a "subtle external concern with another's perception (beside the teacher's) of one's work" (p. 9).

Also of interest from the studies reviewed in this section are the findings regarding gender differences in levels of mathematics anxiety. While there is general agreement that such differences exist, there is some support for the hypothesis that the differeces are due to level of mathematical preparedness rather than innate gender differences.

Confidence and Mathematics Anxiety

Introduction

The studies reviewed in this section support the contention that confidence in mathematical ability is one of the most important factors relating to mathematics anxiety. The definition of mathematics anxiety utilized in this study states that it occurs as a response to a perceived threat to self-esteem. Situations in which persons have confidence in their abilities are not as anxiety-provoking as situations in which there is uncertainty about the outcome. It logically follows that persons lacking in self-confidence in mathematics would perceive situations involving mathematics as threatening.

Gourgey (1984) states that "a substantial pert of math anxiety involves a low self-concept of mathematical ability; thus math anxiety involves not simply fears of hard work, of evaluation by others, of low grades, or dislike of the subject, but fears of failure or inadequacy" (p.15). This statement closely ties in with Byrd's (1982) and this study's conceptualization of mathematics anxiety as a perceived threat to self-esteem. Others have noted the correlation between confidence and self-esteem (Reyes, 1980; Hendel, 1980). Hendel (1980) noted that participants in a mathematics anxiety program rated their mathematics ability as poor, demonstrating low self-confidence.

Frary and Ling (1983), found in their analysis of mathematics anxiety that a scale measuring confidence in learning mathematics loaded on the same factor scale as mathematics anxiety. Other researchers who have empirically explored the relationship in mathematics between confidence and anxiety have all found a significant relationship between mathematics anxiety and confidence in mathematical abilities (Butler & Austin-Martin, 1981; Feinberg & Halperin, 1978; Gourgey, 1984; Hackett 1985). This section will review work by Byrd (1982), Fennema and Sherman (1976), and Frary and Ling (1983). Byrd's study is included because she is one of the few persons who grounds her mathematics anxiety work within a theory of general anxiety. Fennema and Sherman developed the most widely used scale measuring confidence in learning mathematics, and Frary and Ling have provided support for the work of Fennema and Sherman.

Mathematics Anxiety as Self-Doubt

Byrd conducted in-depth interviews with six students, exploring her hypothesis about mathematics anxiety as a perceived threat to self-esteem. Four of the six students were determined to be highly anxious about mathematics based on perceptions from the individuals, their instructors, and the researcher. Participants' selection was later corroborated by scores on the MARS. The remaining two subjects experienced low levels of mathematics anxiety.

Self doubt, a lack of confidence in mathematics ability, and attitudes about mathematics are among the dispositional factors relating to mathematics anxiety identified by Byrd in her interviews. While confidence is specifically related to mathematics, self-doubt is more global in nature. The primary attitude which appeared to influence Byrd's subjects was whether one perceives mathematics as useful. High mathematics anxious subjects tended to view mathematics as not useful, although they would sometimes admit that such an attitude was a rationalization.

Other factors determined to influence the levels of subject anxiety included teacher personality, parental encouragement, negative experiences in mathematics, and test anxiety. From the perspective of mathematics anxiety as self-doubt, test anxiety is also viewed as a threat to self-esteem and so it would be expected that it would correlate with mathematics anxiety. Variables associated with mathematics anxiety stemming from the actual study of mathematics are the pace at which it is taught, and the nature of mathematics. Byrd concluded that while some of her subjects held such misconceptions about mathematics as the belief that it is rigid and uncreative, the sequential, cumulative nature of mathematics was also a factor. If students missed an important concept, it was unlikely that they would fully comprehend successive material.

In conclusion, Byrd (1982) views mathematics anxiety as a fear response to perceived threats to one's self-esteem which are based on the following factors: level of self-doubt, lack of confidence in one's ability to learn mathematics, belief that mathematics is not useful, teacher personality, lack of parental encouragement in mathematics, negative experiences in mathematics, test anxiety, belief in mathematics as rigid and uncreative, and the sequential, cumulative nature of mathematics.

While Byrd's hypothesis of mathematics anxiety rising out of perceived threats to self-esteem is useful, it does not provide a complete understanding of the matter. Her explanation leaves out the complex realtionships among the variables. This study's view of mathematics anxiety as a system, while not incompatable with Byrd's view, provides a more thorough basis for understanding. It is too simplistic to assume that the socialization factors, cognitive style, and the beliefs one holds about mathematics do not also influence levels of mathematics anxiety. On the other hand, one cannot deny the importance of confidence in the system, as the results from empirical studies demonstrate.

Quantitative Studies Regarding Confidence

Frary and Ling (1983) conducted a factor analysis study of Fennema and Sherman's (1976) Mathematics Anxiety Scale in which they examined the relationship between that scale and the following variables: the Fennema/Sherman attitude scales of usefulness of mathematics, confidence in learning mathematics, effectance motivation in mathematics, and attitude toward success in mathematics; Spielberger's Test Anxiety Inventory; Trondahl and Powell's Dogmatism Scale; and Gough's Adjective Checklist. The last of these provides information on a wide variety of personality constructs, including need for achievement, assertiveness, and self-confidence.

Frary and Ling used 491 students enrolled in mathematics courses at a moderately selective state university. The courses were primarily for students enrolled in non-technical curricula, with a few from engineering and architecture. Frary and Ling stated that although it was not a random sample, it was representative of persons from majors not highly quantitative in nature.

Four of the five mathematics attitude scales loaded on the same factor, with only attitude toward success in mathematics being excluded. The only other variable included in this factor was test anxiety, which had a smaller loading than any of the other scales. The three scales loading with mathematics anxiety were usefulness of mathematics, effectance motivation, and confidence in learning mathematics.

Following this factor analysis, Frary and Ling correlated the factors with socioeconomic status, degree to which quantitative skills are required for academic major, maximum level of mathematics attained in high school, gender, approximate college grade point level, and grade in current mathematics course. Significant correlations between the factor scores of maximum level of high school mathematics, college GPA, and current course grade were achieved. None of the factor scores for the other variables achieved statistical significance. The results of this study indicate that variables associated with mathematics anxiety are confidence in and enjoyment of mathematics, perceived usefulness of mathematics, test anxiety, levels of high school mathematics attained, college GPA, and current grade in mathematics work.

In reviewing the literature regarding mathematical self-confidence, there is general support among all reseachers that feelings of confidence in one's mathematical abilities results in lower levels of mathematics anxiety (Fennema & Sherman, 1976, Hackett, 1985). As there is general agreement, no additional studies will be presented.

Summary Regarding Confidence

The literature supports a strong link between mathematical self confidence and mathematics anxiety. There are few variables in this proposed system of mathematics anxiety other than confidence about which there is little or no disagreement as to the part and importance they play. Test anxiety, general anxiety, and effectance motivation in mathematics are the other constructs about which there is general agreement. The forms of anxiety, however, are significantly, but not strongly correlated with mathematics anxiety, and few persons have studied effectance motivation, and so it is difficult to determine its role in the system.

A number of researchers have included self confidence in mathematics with the same results: self-perceived mathematics ability is strongly related to mathematics anxiety. Writers of opinion articles (Gough, 1954; Tulock, 1957), early researchers of attitudes toward mathematics (Fendon, 1958), those empirically studying mathematics anxiety (Frary & Ling, 1983; Hackett, 1985), and theorists (Byrd, 1982) all reach the same conclusions. It is somewhat tempting to take Byrd's stance and conclude that mathematics anxiety can be understood solely as self-doubt. This study will attempt to broaden the understanding of the mathematics anxiety system by including other variables which have not been studied from such different perspectives or upon which there is not total agreement.

Perceived Usefulness of Mathematics

Frary and Ling (1983) and Byrd (1982), in studies previously reviewed, found a link between high levels of mathematics anxiety and the perceived uselessness of mathematics. From the perspective of mathematics anxiety as a threat to self-esteem, it seems logical that persons with higher levels of anxiety would view mathematics as useful. Failure at a task perceived as not useful would engender less intense feelings of self-doubt than would failure at a useful endeavor. Four studies were found which address the connection between mathematics anxiety and the perceived usefulness of mathematics.

Contrary to the findings regarding test anxiety and confidence in mathematics ability, there is not total agreement that persons experiencing higher levels of mathematics anxiety perceive that mathematics is not useful in either their current lives or in their future educational and career activities. Work by Dutton and Blum (1968) and Kincaid and Austin-Martin (1981) do not support the findings of Frary and Ling and Byrd.

Dutton and Blum, whose work is reported in the preceding section regarding early research in attitudes toward mathematics, reported that even students who held negative attiitudes regarding mathematics agreed that it was useful and practical in daily life. There are several possible explanations as to why some studies found that some persons who experience higher levels of mathematics anxiety perceive mathematics to be useful and other studies found that persons who report greater amounts of matematics anxieety have perceptions that mathematics is not useful in daily life.

It may be that the sixth, seventh, and eighth graders in Dutton and Blum's study have not yet developed the defense mechanisms regarding mathematical performance which Byrd hypothesized to be present in her sample. It may also be that the basic mathematics taught in those grades is perceived as more useful than the more abstract coursework in later grades. A third possibility is that this is an example of the differences in attitudes held by persons experiencing higher levels of mathematics anxiety, and that one cannot expect total agreement in all studies.

Kincaid and Austin-Martin (1981), examined the differences in attitudes toward mathematics held by persons experiencing different levels of mathematics anxiety. Their sample of 344 female college freshmen at a private liberal arts college in the midwest took a mathematics achievement test, the MAS and the following scales: confidence in learning mathematics; mother, father, and teacher scales; attitude toward success in mathematics; mathematics as a male domain; and the usefulness of mathematics. Kincaid and Austin-Martin also collected data on the mathematics relatedness of the occupations of the subjects' parents. Students scoring one standard deviation or more below the mean were classified as high anxious. The final sample included 63 persons in the high-anxious group and 53 in the low-anxious group.

As might be expected, the low-anxious goup reported more positive attitudes toward mathematics than did the high-anxious group. Significant correlations were calculated between scores from both groups on the MAS and the following scales: confidence, father, male domain, and attitude toward success. The scales referencing usefulness of mathematics and mother's perceived attitudes, and mathematics achievement were not significanctly related to mathematics anxiety. All of the scales, as well as achievement, were significantly correlated with mathematics anxiety for the low-anxious group.

Kincaid and Austin-Martin then performed an analysis of variance on each of the scales, with mathematics attitude as the dependent measure and level of anxiety as the independent measure. Each of the scales achieved significance except the Attitude Toward Success in Mathematics Scale. The scales achieving the highest probabilities of actual differences were the confidence, usefulness, father, and teacher scales.

The results of the Pearson correlations do not support a relationship between mathematics anxiety and perceived usefulness of mathematics. These results are contradictory to the analyses of variance, which indicate that perceived usefulness of mathematics strongly differentiates high and low mathematics anxious groups. The analyses of variance in this study may have an inflated alpha due to the multiple analyses performed; however, discounting these results leaves the difficulty of explaining the difference between these results and those of Byrd (1982) and Frary and Ling

(1983).

Kincaid and Austin-Martin provide an explanation for this discrepancy. They state the high mathematics anxious group "appears to be less consistent in attitudes held and therefore, less predictable, thereby making the correlates of their mathematics anxiety harder to identify" (1981, p. 7). This conclusion supports the hypothesis that mathematics anxiety is a system with a number of variables working together to form the construct. As levels of mathematics anxiety increase, individual differences become of greater importance.

Acceptance of Misconceptions about Mathematics

Another of the attitudes expressed by Byrd's high math-anxious subjects relates to misconceptions about mathematics. They expressed beliefs that mathematics was rigid and uncreative. Gough (1954) found that students experiencing mathemaphobia held a belief that a "mathematical mind" is necessary for understanding mathematics. Gourgey (1984) conducted a study to test the hypothesis that acceptance of misconceptions about mathematics is positively related with mathematics anxiety.

Gourgey sampled 92 undergraduate and graduate students at New York University who were enrolled in a basic statistics course. In addition to exploring the link between acceptance of beliefs about mathematics and mathematics anxxiety she also examined the relative contributions of beliefs about mathematics, mathematical self-concept, and arithmetic skills to mathematics anxiety and course performance. A third question was whether mathematics self-concept and beliefs about mathematics discriminate among groups based on levels of anxiety and performance.

The Beliefs About Mathematics Scale (BAM) and Mathematical Self-Concept Scale (MSCS) were developed for this project and were judged to have acceptable validity and reliability. Gourgey provided no other information regarding reliability or validity. The MARS was utilized as the dependent measure. Scores on the MARS were significantly correlated with scores on the BAM, and the MSCS. Furthermore, scores on the MARS were significantly correlated with an arithmetic skills test and course achievement, although to somewhat smaller degree.

Based upon their responses to the MARS and the statistics midterm exam, Gourgey divided the participants into four groups: high anxiety, low performance; low anxiety, low performance; high anxiety, high performance; and low anxiety, high performance. Levels of anxiety distinguished between the groups better than any other variable, with the two high anxiety groups reporting less positive mathematical self-concepts. Beliefs about mathematics did not distinguish among the groups, although the high-anxiety groups reported greater acceptance of erroneous beliefs about mathematics.

In her conclusion, Gourgey states that the relationship between beliefs about mathematics and mathematics anxiety may be stronger than these results would make it appear "as many misconceptions may elicit disagreement due to their social unacceptability (for example, statements that women have less ability than men) or because, once on paper, their absurdity is apparent" (1984, p. 14). This conclusion is supported in Byrd's (1982) study by the statement made by one of the high math-anxious students to the effect that she denied the usefulness of mathematics as a defense mechanism. Gourgey did note that of the seven persons who withdrew early from the course, all had scored highly on the BAM scale indicating acceptance of erroneous beliefs about mathematics.

Effectance Motivation in Mathematics

Typically people do not enjoy performing tasks which elicit high anxiety reactions. However, it is a truism in research that even the self-evident must be validated. The only study directly addressing the relationship between effectance motivation, or enjoyment, in mathematics and mathematics anxiety is that conducted by Frary and Ling (1983). As previously stated, in this factor analysis study the following scales loaded on the same factor: confidence in learning mathematics, test anxiety, usefulness of mathematics, mathematics anxiety, and effectance motivation in mathematics. The inclusion of these scales on the same factor indicate they are all related in some manner. It is the hypothesis of this study that this relationship is the system of mathematics anxiety.

It is not unreasonable to assume that persons who enjoy performing mathematical tasks probably do not experience as high levels of mathematics anxiety as do people not enjoying mathematics. Accepting Byrd's hypothesis regarding mathematics anxiety resulting from perceived threats to self-esteem, it logically follows that most people do not enjoy engaging in threatening activities. As with the perceived usefulness of mathematics, this study added to the body of knowledge in this area.

Perceived Parental and Teacher Attitudes

The bulk of evidence regarding the relationship between perceived parental and teacher attitudes toward one as a learner of mathematics and mathematics anxiety comes from the literature regarding attitudes toward mathematics. As may be recalled from an earlier section, Lazarus (1974) placed the primary responsibility for negative attitudes toward mathematics on parents and teachers. He stated that they excused poor performance in mathematics and were instrumental in transmitting their own negative attitudes to children.

Two studies by Poffenberger and Norton (1956, 1959), also validated the importance of perceived parental and teacher attitudes. In their initial study they found that more than half of the respondents stated that their parents expected above average work in most school subjects, but only average work in mathematics and that these lower expectations were due to difficulties experienced by their parents in mathematics. Those students whose parents did not communicate higher expectations reported that they did poorly in mathematics classes. Students who reported high parental expectations for mathematics work stated they did well in mathematics classes. Thus, both parental expectations and parental attitudes had an influence on the attitudes of students.

The results of their second study supported these findings, although downplaying the importance of mothers' perceived attitudes toward mathematics. Encouragement in mathematics and expectations of high performance in the subject from both parents were related with more positive attitudes toward mathematics. Byrd (1982) also found parental encouragement to be an important factor in determining levels of mathematics anxiety.

Fennema and Sherman (1976) recognized the important role parents and teachers play in the development of attitudes toward mathematics and developed scales to measure the impact of their perceived attutudes. As stated previously, Fennema and Sherman did not study the relationship among these perceived attitudes and mathematics anxiety. However, Kincaid and Austin-Martin (1981) did utilize the parental scales in teir study reviewed in a previous section. They did not find a significant Pearson correlation between the mother scale and mathematics anxiety. The analysis of variance of scores on the mother scale by levels of mathematics anxiety achieved statistical significance. With the probability of a Type I error due to probability pyramiding, the meaningfulness of these results is questionable.

Byrd (1982) is the other researcher addressing the influence of teachers and parents on mathematics anxiety. While both of her low math-anxious students reported receiving a lot of parental encouragement in mathematics, only one of the high math-anxious students received such support. This high-anxious subject was encouraged to perform well; however, he was also punished when he did not do well. This resulted in his becoming highly anxious in math classes. Byrd's high math-anxious students also agreed that critical and aloof mathematics teachers fostered negative attitudes toward the subject.

These recent studies provide support for the findings reported in the preceding section dealing with attitudes toward mathematics. According to Poffenberger and Norton (1956), one teacher could have considerable impact on the development of either negative or positive attitudes in a student. It is not whether students liked a teacher, but whether they perperceived the teacher as demonstrating knowledge and enthusiasm about mathematics and concern for their students. Students in Dutton's (1954) study also reported influence from parental attitudes as well as by poor teachers.

It appears then, that while perceived parental attitudes toward mathematics are important, it is the perceived attitudes of fathers which are most important in determining levels of mathematics anxiety. This may be due to the fact that mathematics is seen as a male domain (Fennema & Sherman, 1976), and thus, paternal attitudes toward the subject have greater impact on the learner. It is possible that this belief is changing as society becomes less sterotypical of persons. This matter will be discussed in greater detail in the section concerning gender. Teacher attitudes and competency are also of importance in developing positive or negative attitudes toward mathematics.

Most of the studies emphasizing the importance of social influence on mathematics anxiety are at least 20 years old. Many recent researchers focus on affective, cognitive, and demographic variables, to the exclusion of such social factors as parents and teachers. Consequently, this study included these variables of a social nature.

Mathematical Preparedness and Grades

All researchers who included mathematical preparedness in their studies found it to be significantly correlated with mathematics anxiety. For college students, this variable is generally defined as years of mathematics coursework taken in high school. The fewer courses taken, the higher the levels of anxiety. There is also general agreement that there is a small, but significant, relationship between mathematics anxiety and achievement.

For example, Betz (1978) found that students in basic mathematics courses were significantly more math-anxious than those students in courses requiring more mathematics prerequisites. She also found a general tendency for higher levels of mathematics anxiety to be associated with lower mathematics achievement scores. In his sample of 69 high math-anxious students, Hendel (1980) found a significant correlation between years of high school mathematics and the MARS. The same variable contributed significantly to the multiple regression equation with mathematics anxiety as the dependent variable. In a factor analysis of the MARS (Frary & Ling, 1983), years of high school mathematics and current mathematics course grade loaded on the same factor as the MARS.

From these studies it is evident that there is a relationship among mathematics anxiety, mathematics preparedness, and achievement. What is in question is whether mathematics anxiety causes a person to take fewer courses and make lower grades, or if less exposure to mathematics or failure in courses leads to higher levels of anxiety. It is probable that the relationship goes both ways. Anxiety may lead to avoidance (Aiken, 1970) and lower grades, and lack of preparedness or failure in the subject may also lead to higher levels of anxiety. Viewing mathematics anxiety as a system allows validity for both points. One aspect of a system is its interdependence. A change in one part of the system often results in a change in another part. The changes do not flow in one direction. A change in one part of the mathematics anxiety system, such as failure in a class, may affect another part, such as level of anxiety. Conversely, if other factors raise the level of anxiety, this resulting change may result in lower grades in mathematics classes.

Gender

Unlike the relationships among mathematics anxiety, grades, and preparedness, there are conflicting findings when reviewing the literature regarding gender. This section summarizes the findings of researchers in this area, using these findings to support the hypothesis that gender differences are due to socialization factors rather than innate differences. For those studies which have been previously addressed, only the findings pertinent to gender are presented here.

In their 1961 study, Aiken and Dreger found that attitudes toward mathematics significantly predicted achievement only for women. Behr (1973), utilizing Aiken's scale, also found significant gender differences on the attitude inventory and the SAT quantitative scale. A number of recent studies regarding mathematics anxiety found significant gender differences, with women reporting more anxiety than men (Calvert, 1981; Dew, Galassi, and Galassi, 1983; Sepie &

Keeling, 1978).

Of the studies finding no, or conflicting, gender differences, three will be reviewed here. These three provide support for the hypothesis that gender differences in mathematics anxiety are a result of differences in mathematics background rather than innate gender differences. Other studies which report significant gender differences do not take into account such differences in background.

Betz (1978) studied 652 students at the Ohio State University who were enrolled in either a basic mathematics course, an introductory psychology course, or a precalculus course. She found that the only significant gender differences in mathematics anxiety came from students in the basic mathematics course and the psychology course. Female students in the precalculus course showed no significant differences in levels of mathematics anxiety from the male students.

Brush (1978) also found significant gender differences in one of her two samples studied, but not in the other. She attributed this to the fact that in the second sample there were no differences in mathematical background between the males and females.

Resnick, Viehe, and Segal (1982) conducted a study involving 1106 freshmen at the University of Rochester; administering the MARS, the Strong-Campbell Interest Inventory (SCII), and a mathematics placement test. Students were enrolled in five different mathematics courses, all of which were at least at a pre-calculus level. MARS scores correlated significantly with the academic orientation and with the mathematics interest scales of the SCII. Results from a multiple regression analysis on the effects of course enrollment and scores on the the MARS on course achievement revealed no meaningful results.

In order to test gender differences, the researchers computed t-tests on MARS scores by gender for each class. None of the results achieved statistical significance, indicating that there are no differences on MARS scores between men and women who are enrolled in higher level mathematics courses. These results match those of Betz and Brush, who found that women enrolled in higher level mathematics courses showed no significant differences in levels of mathematics anxiety than men.

One conclusion which can be drawn regarding mathematics anxiety and gender is that when information regarding the mathematical background of participants is available, gender differences disappear. This conclusion is supported by recent work concerning mathematics and gender which demonstrates that gender differences in mathematics are due to such socialization factors as the view of mathematics as a male domain and women are not supposed to be smart (Aiken, 1974; Fennema & Sherman, 1977). As more women are encouraged (or not discouraged) to take higher-level mathematics courses, gender differences in achievement are disappearing. Based on this socialization hypothesis, this study covaried the effects of mathematical preparedness to determine if gender differences are present in mathematics anxiety.

Cognitive Style

As stated in the previous chapter, there is one factor not addressed in the current literatuure, but of seeming importance to mathematics anxiety, cognitive style. The following section presents a rationale for including this variable in the present study.

Cognitive style is defined as:

> the characteristic, self consistent modes of functioning which individuals show in their perceptual and intellectual activities. These cognitive styles are manifestations in the cognitive sphere of still broader dimensions of personal functioning which cut across diverse psychological areas (Witkin, Oltman, Raskin, & Karp, 1971).

Research in cognitive styles began during the 1940's in laboratory tests of perception in which persons attempted to orient a pole along an upright axis in spite of contradictory sensory input. Experimenters noted that persons tended to make consistent errors across trials, suggesting that people had preferred ways of assessing information. As research broadened in the area, researchers found that these preferred styles were not limited to perception of the upupright, but were utilized across many perceptual and cognitive tasks. Witkin and Goodenough (1981) suggest that cognitive style is a misnomer and the phenomena is better labeled autonomy of external refferents; however, the earlier label has stuck.

Witkin and Goodenough (1981) state that one of the primary differentiations in cognitive style is between field dependence and field independence. They provide the following reasons for utilizing this distinction: 1) the demonstrated breadth of the dimension and evident representation in everyday life, 2) the existence of effective procedures for its assessment, and 3) the availability of a theoretical framework which makes it possible to bring together a wide variety of psychological phenomena and functions often considered separate.

Witkin and Goodenough make the point that the distinction is bipolar, that is, neutral in value. There are, however, distinguishing characterstics of each mode of perception. Field independence is considered to be an impersonal orientation. Individuals who are field independent are more self-reliant and autonomous; they demonstrate greater hemispheric differentiation and tend to enter more technical fields of endeavor. Persons operating from this orientation are associated with a certain coldness and distance in their relationships with others.

Persons labeled field dependent rely on external cues for decision making and have a more interpersonal orientation. They experience difficulty in abstract problem solving when required to pull essential information out of context. Persons functioning from this orientation seek physical closeness with others, and are more open and accommodating in their relationships with others. They tend to seek employment in fields such as education and the social services.

Persons who are field independent tend to be high in analytic and spatial visualization abilities while field dependent persons are corresepondingly low in those areas (Witkin & Goodenough, 1981). These abilities are among those which are necessary for success in mathematics (Elmore & Vasu, 1979; Sherman, 1971). A study by Vaidya and Chansky (1980), demonstrated that students who are field dependent are likely to perform worse in mathematics classes than those who are field independent. These findings are supported by a study conducted by Roberge and Flexer (1983). Slatterly (1976) states that it is not so much that a high field independent orientation is useful in mathematics as a primarily field dependent orientation is a hindrance.

The previous section regarding the relationship among mathematical preparedness, grades, and mathematics anxiety suggested a link between mathematics anxiety and achievement in mathematics courses. As persons who are field dependent are likely to perform worse in mathematics courses than persons who are field independent, it does not seem unreasonable to hypothesize that there is a correlation between field dependence and mathematics anxiety.

Moreover, a study involving 240 freshmen found a significant correlation between field dependence and anxiety, with persons scoring higher on a measure of field dependence also scoring higher on a measure of anxiety (Bergum, 1980). As previously stated, although general anxiety and mathematics anxiety are not the same construct,they do overlap (Betz, 1977; Hendel, 1980; Rounds & Hendel, 1980). Thus, although there is not yet an empirical link established between cognitive style and mathematics anxiety, it is not unreasonable to hypothesize that persons who are field dependent experience higher levels of mathematics anxiety.

Summary and Conclusions

Chapter I of this proposal presented the following definition of a system: "a complex unity formed of many often diverse parts subject to a common plan or serving a common purpose;...an aggregation or assemblage of objects joined in regular interaction or interdependence" (Webster's Third New International Dictionary, p.2322).

If mathematics anxiety is a system, as thus defined, there are three primary criteria which should be met. The first is that it should be complex and made up of many, possibly diverse, parts. There is little question, given the large number of variables associated with mathematics anxiety, that it is complex. The inclusion of variables from affective, cognitive, and behavioral areas satisfies the diversity criteria. The second criteria is that this complex unity of variables serve a common purpose. There appears to be general consensus that the variables reviewed in this chapter form an entity labeled mathematics anxiety. The third criteria is that these variables be joined in regular interaction or interdependence. The differing results found when different components of the system are studied lend support for this criteria. For example, gender differences appear in a different light when studied in conjunction with mathematical preparedness. It appears, then, that mathematics anxiety meets the criteria and may be conceptualized as a system.

This review of the literature began with a definition of mathematics anxiety as a system of cognitive, affective, and behavioral responses to threats to self-esteem brought about as a response to situations involving mathematics. Following this was a review of the early literature regarding attitudes toward mathematics. The primary findings from this review were that persons holding less positive attitudes toward mathematics were afraid of failure, had not been encouraged in their mathematics work by their parents or teachers, and were possibly not as psychologically healthy as persons holding more positive attitudes toward mathematics.

In the review of current literature, there was general agreement that test anxiety, confidence in one's mathematics ability, enjoyment in performing mathematical tasks, and number of high school mathematics courses taken were all associated with mathematics anxiety. The presence of these variables supports the hypothesis that for persons experiencing greater levels of mathematics anxiety, mathematics is a threat to self-esteem. The less confidence one has, the more one is afraid of evaluation. The less exposure in an area, the less opportunity to gain competence. It is not unreasonable to assert that persons do not enjoy performing tasks towards which one feels anxiety.

There is not total agreement as to whether the presence of the following variables significantly predict levels of mathematics anxiety: perceptions of the usefulness of mathematics, maternal support and encouragement, acceptance of misconceptions about mathematics, and gender. As presented in a preceding section, perceptions concerning the usefulness of mathematics can be interpreted two ways, neither of which can be confirmed utilizing existing data.

The first interpretation is that persons experiencing higher levels of mathematics anxiety believe mathematics to be useful, and their anxiety stems from their lack of confidence in an important subject area. The view of mathematics as not useful is a psychological defense. This hypothesis is partly supported by statements from Byrd's (1982) subjects. The second hypothesis is mathematics is truly believed not to be useful. Students with more mathematics anxiety experience difficulty in being evaluated in an area which is not beneficial. Thus, a failure at a mathematics task is a blow to self-esteem, while success is meaningless, since the subject is unimportant.

Conflicting findings regarding maternal influence and gender may be ecplained by means of the rationale presented in the section on gender. Gourgey (1984) provides an explanation for conflicting findings regarding acceptance of misconceptions about mathematics. Many erroneouus belies about mathematics may be accepted, however, when attempts are made to measure them by means of an inventory, they appear so absurd, respondents do not answer honestly.

The quantity of variables, as well as conflicting results regarding the presence or strength of certain variables, lends support to the systems view of mathematics anxiety. The conflicting results regarding some variables may be taken as evidence that the system of mathematics anxiety is complex and susceptible to individual differences. This conclusion is supported by Kincaid and Austin-Martin (1981), who found that persons experiencing higher levels of mathematics anxiety are not a homogeneous group. While two persons may experience similar levels of mathematics anxiety, the precipitating causes may be very different.

A fault common to many of these studies is their inadequate statistical analyses. There has been a trend to be content with simple correlations or multiple analyses of variance. The use of such procedures do not take into consideration shared variance Type I error pyramiding. Another fault is the limited scope of the studies. Many have focused on several variables to the exclusion of others found to be of importance. For instance, Poffenberger and Norton (1956, 1959) focused on the social aspects of the problem, while Aiken and Dreger (1961) studied personality variables. Viewing mathematics anxiety as a system, it is important to include variables from cognitive, affective, and demographic areas. The scope of this study is such that it takes the shortcomings of previous research into account and corrects for them. Variables from all areas of the system of matheamtics anxiety are included. The statistical procedures take into consideration shared variance by utilizing a multiple regression analysis.

CHAPTER III

METHODOLOGY

Introduction

This chapter presents the specific methodologies used to conduct this study. Topics discussed include the characteristics of the sample, the instruments used in gathering data, and the specific procedures which were followed in collecting the data.

Subjects

Participants in this study were students in seven sections of introductory sociology at Oklahoma State University in the Fall semester of 1987. Introductory sociology was chosen because this class is designated by Oklahoma State University as appropriate to satisfy one of the university general education requirements. Therefore, students in this course represent a number of fields of study and mathematical backgrounds. Classes were selected by asking graduate teaching assistants in the Sociology Department for permission to use their classes. Four teaching assistants agreed for their classes to be used.

A total of 283 people participated in the study, including 125 women, 148 men, and 10 persons not indicating gender. The reported number of math courses taken in high school by the students ranged from one to seven, with an average of 3.9 courses reported. This average is quite high. In examining the data, it appears that students indicated all mathematics classes they had taken, and not limiting their reporting to classes taken in high school. Refer to Table 1 on page 78 for the major fields of study reported by males and females.

Instruments

The following is a list of the independent variables in this study as well as the instruments used to measure them:

1) a revised version of the Mathematics Anxiety Rating Scale (MARS) developed by Plake and Parker (1982) to measure mathematics anxiety;

2) the Test Anxiety Inventory (TAI) developed by Spielberger (1977) to measure test anxiety;

3) the Fennema and Sherman (1976) scales measuring confidence in learning mathematics, effectance motivation in mathematics, perceived usefulness of mathematics, and perceptions of paternal, maternal, and teacher attitudes toward one as a learner of mathematics to measure the variables of the same names;

4) the Group Embedded Figures Test (GEFT) developed by Witkin, Oltman, Raskin, and Karp (1971) to assess cognitive style; and

TABLE 1

MAJOR FIELDS OF STUDY OF PARTICIPANTS BY MALES AND FEMALES

Field of Study	Females Number	Females %	Males Number	Males %	Total
Business	36	33%	74	67%	110
Engineering/ Technology	4	16%	21	84%	25
Home Economics/ Family Relations	16	84%	3	16%	19
Physical/ Biological Science	13	54%	11	46%	24
Journalism	4	36%	7	64%	11
Other, Arts and Science	27	71%	11	29%	38
Undeclared	25	54%	21	46%	46
Total	125		148		273

5) the Beliefs About Mathematics (BAM) scale developed by Gourgey (1984).

Information regarding gender and number of mathematics courses taken in high school were assessed by self-report items on the questionnaires. A copy of the data collection instruments, with the exception of the GEFT and TAI, are located in Appendix A.

Revised MARS

Introduction

Before discussing the revised MARS, the full-scale version of the scale will be described. Suinn, Edie, Nicoletti, and Spinelli (1971), recognized the need for a measure of the anxiety specific to mathematics in order to provide an accurate tool for research and evaluation. They developed one of the most widely used measures of mathematics anxiety, the Mathematics Anxiety Rating Scale (MARS). The MARS is a 98-item scale which presents activities relating to mathematics such as: "calculating a simple percentage, e.g., the sales tax on a purchase", "being given a set of multiplication problems to solve", and "buying a mathematics textbook." Respondents are asked to state how much each situation frightens them on a five-point scale from "Not at all" to "Very much." The subject's points are added with high scores reflecting higher levels of mathematics anxiety.

Validity of the MARS

Richardson and Suinn (1972) report that the MARS is useful in determining the success of anxiety-reduction programs and in research, such as the present study, to explore the system in more detail. Validity was assessed in three studies in which there were significant decreases in scores on the MARS following behavior treatment for mathematics anxiety. The same authors report another study in which scores on the MARS were compared with scores on the mathematics portion of the Differential Aptitude Test. Scores on the MARS correlated -.64 ($p < .01$) with scores on the Differential Aptitude Test (n=30). Ricardson and Suinn reason that "since high anxiety interferes with performance, and poor performance produces anxiety, this result provides evidence that the MARS does measure mathematics anxiety" (p. 553, 1972). Other researchers (Suinn, Edie, Nicoletti, & Spinelli, 1971) report that the mean MARS score for persons requesting counseling for mathematics anxiety was 1.25 standard deviations above the normative mean. These results support the use of the MARS as a measure of mathematics anxiety.

Reliability of the MARS

Richardson and Suinn's (1972) reports of reliability for the MARS include a Cronbach's alpha of .96 (n=397) and a test-retest coefficient of .85 (n=35). Suinn et al.

(1971) reported a two-week test-retest reliability of .78 from a sample of 119 college students. In their investigation of mathematics anxiety, Dew, Galassi, and Galassi (1981) calculated a Cronbach's alpha of .96 and two-week test-retest reliability of .87 from a sample comprised of 769 students. The results of these studies indicate that the MARS is both a valid and reliable measure of mathematics anxiety.

Revised MARS

Plake and Parker (1982) were interested in an efficient measure of mathematics anxiety in statistics or other mathematics courses, but in a briefer form than the 98-item MARS. They selected questions from the full-scale MARS which they felt measured anxiety related to mathematics coursework and administered both scales to 170 students enrolled in three introductory statistics classes. The mathematical background of the subjects varied substantially.

A factor analysis of the revised scale revealed two factors, similar to those found in the full-scale MARS by Rounds and Hendel (1980). Each item on the final version of the revised scale loaded on only one of the factors. The scale demonstrated internal consistency (coefficient alpha) of .98 and the correlation between scores on the revised scale and the full scale MARS was .97. Plake and Parker concluded that their revised scale is a valid substitute for the full-scale MARS for measuring course-related mathematics anxiety.

In order to further assess the usefuless of the revised MARS, In April, 1987, a pilot study was in conducted at Ok-Oklahoma State University. Forty-one students enrolled in an upper level education course completed both the full-scale MARS and the revised MARS. Two weeks later the same group again completed the revised MARS. The correlation coefficient between the MARS and the revised MARS taken on the same day was .92. A two-week test-retest reliability coefficient between the revised MARS scales was .91. Using data from the present study, a Chronbach's alpha of .94 was calculated for the revised MARS.

Test Anxiety Inventory

The Test Anxiety Inventory (TAI) was designed by Spielberger in 1977 to measure anxiety relating to test-taking as a situation-specific personality trait. This 20-item inventory is comprised of three scales, worry, emotionality, and total. Examples of items on the TAI include "thoughts of doing poorly interfere with my concentration on tests" and "during tests I feel very tense."

In a review of the instrument, DeVito (1984) reported two-week and one month test-retest reliabilities of .80 and .81, respectively, for samples of high school, undergraduate, and graduate students. Internal consistency (coefficient alpha) of .92 for males and .96 for females were also reported. The Chronbach's alpha calculated for the current sample was .91.

In examining concurrent validity, the TAI was found to be correlated .82 with Sarason's Test Anxiety Scale. Correlations between .61 and .86 have been reported between the TAI and the State-Trait Anxiety Inventory (STAI). These lower correlation coefficients are to be expected since the TAI measures a more specific form of anxiety than that measured by the STAI.

DeVito concludes his review of the TAI by stating:

> this reviewer regards the TAI to be by far the best psychometric instrument for measuring TA. This judgement is based on the soundness of the test construction procedures employed, the validity and reliability evidence, and the available normative data (1984, p.680).

DeVito does express reservations regarding the validity of using the worry and emotionality subscales due to the limited and mixed discriminant validity evidence. His conclusion is that the subscales should be retained without giving them undue emphasis.

Fennema/Sherman Scales

Introduction

Six of the scales utilized in this study were developed by Fennema and Sherman (1976). These are the confidence in learning mathematics, effectance motivation, mathematics usefulness, mother, father, and teacher scales. Each of the scales has twelve items, six of them worded positively and six worded negatively. As they were developed and normed together, this section will begin with a description of how the scales were developed before the individual characteristics of each scale are presented.

Confidence in Learning Mathematics Scale

This scale is "intended to measure confidence in one's ability to learn and perform well on mathematical tasks" (Fennema & Sherman, 1976, p. 4). Items include "I am sure I could do advanced work in mathematics," and "for some reason, even though I study, math seems unusually hard for me."

Effectance Motivation Scale

This scale measures attitudes concerning involvement in and enjoyment of mathematics. Items include "the challenge of math problems does not appeal to me" and "when a question is left unanswered in math class, I continue to think about it afterward."

Mathematics Usefulness Scale

The Mathematics Usefulness Scale is designed to measure the perceived usefulness of mathematics as well as its relationship to future education and careers. Items on the scale include "I study mathematics because I know how useful it is" and "I see mathematics as a subject I will rarely use in my daily life as an adult."

Mother and Father Scales

These two scales were designed to measure students' perceptions of their mothers'/fathers' interest, encouragement, and confidence in the students' abilities. Also included are perceptions of parent's attitude toward mathematics. Items on the scales include "my mother thinks advanced math is a waste of time for me," "my father hates to do math," and "my mother has strongly encouraged me to do well in mathematics."

Teacher Scale

The teacher scale measures a student's perception of teachers' attitudes towards them as a learner of mathematics. Similar to the mother and father scales, this scale includes teacher interest, encouragement, and confidence in the student's ability. Sample items include "math teachers have made me feel I have the ability to go on in mathematics," and "getting a mathematics teacher to take me seriously has usually been a problem."

Reliability and Validity

Items on the scales were written independently by the authors, who kept only those items which they both agreed related to the concept being measured. The original scales contained approximately 20 items each. These scales were administered to 367 high school subjects in a middle-class, suburban school. Included in the sample were both students enrolled and students not enrolled in mathematics classes.

The following criteria were used in determining the items included in the final version of the scales: items which correlated highest with the total scores, items with the highest standard deviations, items yielding results consistent with the theoretical construct of the scale, and items which differentiated mathematics and non-mathematics students.

The split-half reliabilities for the scales reported by Fennema and Sherman are as follows: confidence in learning mathematics, .93; effectance motivation in mathematics, .87; usefulness of mathematics, .88; mother, .86; father, .91; and teacher, .88. The correlations among the scales ranged from .34 to .66. The Chronbach's alpha coefficients calculated for the scales using data collected for this study are: confidence in learning mathematics, .92; effectance motivation in mathematics, .90; usefulness of mathematics, .83; mother, .84; father, .83; and teacher, .80.

Although originally developed for use with high school students, a number of researchers have utilized these scales with college populations (Frary & Ling, 1983; Kincaid & Austin-Martin, 1981). In accordance with the developers' instructions when two or more scales are used, items from the three scales were randomly distributed within one scale.

Beliefs About Math Scale

Gourgey (1984) developed the Beliefs About Mathematics (BAM) Scale to address the hypothesis that persons experiencing higher levels of mathematics anxiety also accept misconceptions about mathematics. The 17 item scale contains items from the following catagories of misconceptions: mathematics is separate from and irrelevant to other areas of life, mathematics is precise and mechanical, mathematics represents the only real intelligence, mathematics is a masculine activity, mathematics requires a good memory, and mathematics requires a unique type of thinking process. The items were developed based upon Gourgey's research into the area as well as written comments from students in basic mathematics courses. The final scale resulted after two pilot studies.

Estimates for validity of the scale are based upon the research by which means Gourgey selected the items. She also conducted a factor analysis of the items, the resulting factors of which approximated the original catagories selected for the scale. Gourgey did not report reliability measures for the scale. The estimate of split-half reliability based upon the data collected in this study is .73.

Group Embedded Figures Test

The development of the GEFT (Witkin, Oltman, Raskin, & Karp, 1971) was based in the assumption that a person's

> ...experience of stimulus configurations, experience in the domain of symbolic representations, experience of one's own body, experience of the self and experience which is the product of the operation of defenses as they mediate the relation between ideation and affect (Witkin, et al., 1971, p. 14)

can be tapped by measuring a person's experience in any one of the domains. The authors of the GEFT assert that the wide range of a person's cognitive style can be measured by examining his or her ability to separate figures from an embedded context.

The GEFT consists of a booklet which has 18 complex figures containing simpler geometric shapes. Subjects are directed to locate the simple figures contained in the more complex shapes. There are three practice figures and a series of practice problems. The scored instrument contains two five minute sessions each containing nine items.

The developers report a Spearman-Brown correlation of .82 between the two section scores of a sample of 397 college students. The measures of validity for the GEFT relate to the correlation between scores on it and the scores on the Embedded Figures Test (EFT). Correlations between scores on the two tests of -.82 for men and -.63 for women were reported. The negative correlations are due to the reverse scoring procedures used with the GEFT.

The developers conclude that the "combined evidence suggests that the GEFT may prove to be a useful substitute for the EFT when individual testing is impractical" (Witkin et al., 1971, p.29). However, they go on to caution that the GEFT is still a research instrument and more study is needed on the test.

Demographic Data

In addition to the scales described above, the participants were requested to give information regarding gender, major field of study, and the specific mathematics courses taken in high school. Furthermore, participants were asked to provide information regarding specific incidents which they recall which led to increased anxiety regarding mathematics, or things which assisted the respondent to feel more comfortable with mathematics.

Procedures

Students in introductory sociology classes were asked to participate in a research study regarding attitudes toward mathematics. They were assured of anonymity and told that they could stop working on the instruments at any time. The packets containing the GEFT and the questionnaires were distributed and pencils were given to those people who did not have one. The standardized instructions for admisitering the Group Embedded Figures Test (Witkin et al., 1971) were used. When finished with the GEFT, the respondents completed the questionnaires which were then collected.

Approximately 25 students in the classes chose not to participate in the study. Another seven took the instruments when they were distributed, but did not complete the GEFT or fill in the qustionnaires.

The GEFT was scored according to the procedures given by the authors. These GEFT scores, along with the demographic information and responses to each item on the other scales, were used as the data for the analysis.

CHAPTER IV

RESULTS

This chapter presents an overview of the research design used in this study, the means and standard deviations for the scales, and the results of the data analyses.

Research Design

A correlational research design was used. The purpose for this type of design is to investigate the "... extent to which variation in one factor corresponds with variation in one or more other factors based on correlational coefficients" (Isaac & Michael, 1981, p. 49). Isaac and Michael further state that correlational research is most appropropriate when the variables are complex and/or they do not lend themselves to a true experimental design.

Advantages of this design are that it allows for the measurement of a number of variables and their relationships in a realistic setting and it provides information regarding the degree of relationship among the variables. Limitations of the correlational model are that it does not identify cause and effect relationships, there is less control over independent variables, and there is the danger of identifying relational patterns which have little or no validity or reliability. As this is an exploratory study, the intent is not to detect cause and effect relationships. Indeed, the conceptualization of mathematics anxiety as a system precludes thinking in strict cause and effect terms. The limitation of most concern in this study is that regarding the danger of identifying relational patterns which have little or no validity or reliability.

Scale Means

The means and standard deviations for the eight scales and the Group Embedded Figures Test (GEFT) are reported in Table 1 on page 93. On the revised version of the Mathematics Anxiety Rating Scale (MARS-R) and the Test Anxiety Inventory (TAI) higher scores indicate greater levels of anxiety. On the six Fennema and Sherman scales, mother, father, teacher, usefulness, confidence, and effectance motivation, lower scores denote less positive attitudes. Higher scores on the Beliefs About Math (BAM) scale reflect greater acceptance of misconceptions about math, and lower scores on the GEFT denote greater Field Dependence.

Tests of Hypotheses

The data analyses for study was accomplished in three parts. The first analysis consisted of a Pearson correlation matrix calculated to examine the correlations among the variables. Second, an analysis of covariance was calculated to determine the effects of gender on mathematics anxiety

TABLE 2

MEANS AND STANDARD DEVIATIONS OF SCALES

	TOTAL		FEMALE		MALE	
	MEAN	SD	MEAN	SD	MEAN	SD
MARS[a]	57.62	18.96	62.82	18.24	53.18	18.52
GEFT[b]	10.57	4.80	9.40	4.65	11.45	4.74
TAI[c]	43.67	13.65	46.24	13.72	41.37	13.03
FATHER[d]	45.12	7.79	44.96	7.85	45.34	7.77
MOTHER[e]	43.55	8.02	42.98	7.86	44.03	8.20
TEACH[f]	41.34	7.08	40.56	7.13	41.89	6.96
USE[g]	45.25	7.91	43.74	7.94	46.31	7.61
EFF[h]	35.51	10.73	32.62	11.25	37.63	9.68
CON[i]	39.47	11.25	35.06	11.46	42.99	9.66
BAM[j]	51.93	8.08	52.19	8.20	51.64	8.00

a MARS is Mathematics Anxiety Rating Scale-Revised.
b GEFT is Group Embedded Figures Test.
c TAI is Test Anxiety Inventory.
d FATHER is Perceptions of Father's Attitude Toward One as a Learner of Mathematics Scale.
e MOTHER is Perceptions of Mother's Attitude Toward One as a Learner of Mathematics Scale.
f TEACHER is Perceptions of Teacher's Attitude Toward One as a Learner of Mathematics Scale.
g USE is Perceived Usefulness of Mathematics Scale.
h EFF is Effectance Motivation in Mathematics Scale.
i CON is Confidence in One's Mathematical Ability Scale.
j BAM is Beliefs About Math Scale.

with number of high school mathematics courses as the covariate. Third, in order to determine which of the independent variables contributed significantly to the system of mathematics anxiety, a stepwise multiple regression analysis was computed. A stepwise analysis was used in order to determine which of the variables, if any, contributed the most variance to mathematics anxiety. An alpha level of .01 was selected for all the analyses in order to account for the possibility of Type I error pyramiding.

Hypothesis 1

Null Hypothesis 1: There are no significant correlations between mathematics anxiety and each of the following variables: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics 6) gender, 7) percept-perceptions of paternal attitudes towards one as a learner of mathematics, 8) perceptions of maternal attitudes towards one as a learner of mathematics, 9) perceptions of teacher attitudes towards one as a learner of mathematics, 10) number of mathematics courses taken in high school, and 11) cognitive style.

The first hypothesis may best be conceptualized as being made up of 11 sub-hypotheses. These sub-hypotheses are the paired relationships between mathematics anxiety and each of the independent variables. The hypothesis was tested by means of Pearson product-moment correlations calculated among the above-listed varibles. The results of this analysis are reported in Table 3 on page 96. In examining this table one may see that all variables are significantly correlated ($p < .001$) with the MARS-R. Using Cohen's (1977) formula for computing the power of correlational analyses, the power of the correlation analyses between the MARS-R and all of the independent variables is estimated to be at least .80.

Those correlations between the MARS-R and other variables which exceed .33 have an estimated power of more than .995. These variables are the Test Anxiety Inventory, perceptions of teacher attitudes, perceived usefulness of mathematics, confidence in one's mathematics ability, and effectance motivation in mathematics. Null Hypothesis 1 is therefore rejected.

Hypothesis 2

Hypothesis 2: There is no gender difference in reported levels of mathematics anxiety when the number of mathematics courses taken in high school is statistically controlled.

This hypothesis was tested by means of an analysis of covariance. Mathematics anxiety is the dependent variable, gender is the independent variable, and number of years of high school mathematics is the covariate in this analysis. Refer to Tables 4 on page 98 for the frequency distribution

TABLE 3

PEARSON CORRELATION COEFFICIENTS CALCULATED BETWEEN EACH PAIR OF VARIABLES

	GEFT	GENDER	NOHSMA	TAI	FATHER	MOTHER	TEACH	USE	EFF	CON	BAM[k]
MARS-R[a]	-.30**	-.25**	-.27**	.58**	-.29**	-.32**	.42**	-.36**	-.56**	-.63**	-.31**
GEFT[b]		.21**	.26**	-.31**	.17*	.24**	.32**	.21**	.35**	.40**	.31**
GENDER			.15*	-.17*	.02	.07	.09	.16*	.23**	.35**	-.03
NOHSMA[c]				-.25**	.26**	.28**	.30**	.11	.24**	.37**	-.00
TAI[d]					-.24**	-.28**	-.36**	-.21**	-.43**	-.52**	-.28**
FATHER[e]						.82**	.65**	.61**	.47**	.54**	.13
MOTHER[f]							.73**	.69**	.58**	.63**	.22**
TEACH[g]								.63**	.65**	.75**	.30**
USE[h]									.62**	.58**	.33**
EFF[i]										.77**	.42**
CON[j]											.36**

Note: * $p<.01$.
** $p<.001$.

a Mathematics Anxiety Rating Scale-Revised.
b Group Embedded Figures Test.
c Number of High School Math Courses.
d Test Anxiety Inventory.
e Perceptions of Father's Attitude Toward One as a Learner of Mathematics Scale.
f Perceptions of Mother's Attitude Toward One as a Learner of Mathematics Scale.
g Perceptions of Teacher's Attitude Toward One as a Learner of Mathematics Scale.
h Perceived Usefulness of Mathematics Scale.
i Effectance Motivation in Mathematics Scale.
j Confidence in One's Mathematical Ability Scale.
k Beliefs About Math Scale.

of high school mathematics courses by gender. Males reported taking 604 mathemataics courses and females reported taking 455 mathematics courses.

The results of the analysis of covariance were significant ($F(1,261) = 14.66$, $p<.0001$) and are reported in Table 5 on page 98. The mean score on the MARS-R for women is 62.82 and for men is 53.19. The power of the analysis, is estimated to be in excess of .98 (Cohen, 1977). Null Hypothesis 2 is therefore rejected.

Hypothesis 3

Hypothesis 3: The following variables do not enter a multiple regression analysis as significant predictors of mathematics anxiety: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics 6) gender, 7) perceptions of paternal attitudes toward one as a learner of mathematics, 8) perceptions of maternal attitudes toward one as a learner of mathematics, 9) perceptions of teacher attitudes toward one as a learner of mathematics, 10) number of mathematics courses taken in high school, and 11) cognitive style.

This hypothesis was tested by means of a stepwise multiple regression analysis with alpha-to-enter set at .01. Refer to Table 6 on page 100 for the results of this analysis.

TABLE 4

FREQUENCY DISTRIBUTION OF HIGH SCHOOL MATH COURSES TAKEN BY MALES AND FEMALES

	NUMBER OF MATH COURSES TAKEN								
	1	2	3	4	5	6	7	GRAND TOTALS	TOTAL NUMBER COURSES TAKEN
GENDER									
Female	8	13	33	44	18	7	2	125	455
Male	7	18	27	42	23	20	11	148	604
COLUMN TOTALS	15	31	60	86	41	27	13	273	1059
TOTAL COURSES TAKEN	15	62	180	344	205	162	91		

TABLE 5

RESULTS OF ANALYSIS OF COVARIANCE MARS BY GENDER

Variables	df	Sum of Squares	Mean Square	F	Sig. of F
Covariate[a]	1	6676.66	6676.66	20.84	.0001
Gender	1	4696.75	4696.75	14.66	.0001
Residual	261	83605.95	320.33		
Total	263	94979.36	361.138		

a number of high scool math courses taken

Confidence in learning mathematics entered the equation on the first step, achieving a multiple R of .62 and a multiple R square of .39. Test anxiety entered the equation on the second step, resulting in a multiple R of .69 and a multiple R square of .48. This indicates a change in the multiple R square of .09. On the third and final step, the effectance motivation scale entered the equation. This variable resulted in a multiple R change of .01, bringing the multiple R to .71 and the multiple R square to .50. None of the other variables met the entrance criteria.

Using Cohen's (1977) power analysis for multiple regression, this analysis achieved a power of greater than .995. The results of this analysis support a rejection of the null hypothesis as three of the eleven variables entered the equation.

Summary

The three primary hypotheses of this study were examined using Pearson-product moment correlations calculated between pairs of variables, analysis of covariance, and stepwise multiple regression analysis. The results of these analyses provided support for rejecting the first, second and third null hypotheses. In the first analysis, all of the dependent variables achieved significant correlations with mathematics anxiety. The variables test anxiety, perceptions of teacher attitudes and the usefulness of mathematics, self-confidence in performing mathematics,

TABLE 6

STEPWISE REGRESSION RESULTS

	Variables Entering the Equation	R	B	Beta	df	F	Sig of F
Step 1							
	Confidence	.62	-1.05	-.62	1, 229	143.97	.0001
Step 2							
	Confidence	.70	-.72	-.42	2, 228	108.05	.0001
	Test Anx.		.53	.37			
Step 3							
	Confidence	.71	-.47	-.27	3, 227	76.13	.0001
	Test Anx.		.52	.36			
	Eff. Mot.[a]		-.35	-.20			

a Effectance motivation scale

and effectance motivation in mathematics all achieved correlations of .33 or above with mathematics anxiety.

The analysis of covariance demonstrated that women in this sample experienced higher levels of mathematics anxiety than did the men even when controlling for the number of mathematics courses taken in high school. Finally, in the multiple regression analysis, the variables of self-confidence in mathematics, test anxiety, and effectance motivation in mathematics made significant contributions to mathematics anxiety. Chapter IV presents the conclusions drawn from these analyses.

CHAPTER V

CONCLUSIONS

Introduction

The study of mathematics anxiety as an educational phenomena had its beginning in the 1950's (Gough, 1954). Since that time researchers have studied the construct from various perspectives and reached results which at times conflicted with the findings of other researchers. The present study continued the examination of the phenomena by hypothesizing that mathematics anxiety is system made up of a number of cognitive, affective, behavioral, and demographic factors.

This chapter contains five sections. The first is a general overview of the concerns regarding the validity of the study. The second section presents a discussion of the results pertaining to the specific hypotheses presented in the preceding chapter. Included here is a discussion as to the practical significance of the findings regarding the view of mathematics anxiety as a system. The third part of the chapter discusses other findings resulting from the study. The fourth section reports conclusions regarding mathematics anxiety which are based upon the results of the study. The fifth and final section of this chapter contains recommendations based on the results of the study.

Validity of the Study

Chapter 3 contained a brief discussion of the weaknesses of correlational studies in general. The present section of this chapter presents concerns regarding this study in particular. The first concern relates to the nature of the data collection instruments. There is always some question as to the validity of self-report questionnaires. Specific to this study is the length of the survey form and the similarity of many items on different instruments. Several students remarked that they answered the same question more than once, although in reality no item appeared more than once.

Another concern relates to the data collection process. In five of the seven classes surveyed, the instructors remained in the room during the procedures. One instructor, who taught two classes, did not attend class on the days the data was collected. It was from these classes that the most people refused to participate, and some people left the class when they were told that participation was voluntary. It is not known what effect the nature of the instruments or the dissimilarities in the data collection process had upon the results of this study.

Discussion of Specific Hypotheses

Hypothesis 1

An examination of the Pearson correlations calculated between mathematics anxiety and each of the eleven independent variables resulted in a rejection of the first null hypothesis, there are no significant correlations between mathematics anxiety and each of the following variables: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics, 6) gender, 7) perceptions of paternal attitudes toward one as a learner of mathematics, 8) perceptions of maternal attitudes toward one as a learner of mathematics, 9) number of mathematics courses taken in high school, and 11) cognitive style. All of the independent variables achieved signigicant correlations with mathematics anxiety, and the correlations were generally in the expected directions. The only unexpected finding is the direction of the correlation between the teacher scale and mathematics anxiety. The positive correlation between these two variables indicates that persons with higher levels of mathematics anxiety perceive teachers to be more intersted, supportive and confident in the student's ability. This finding is difficulat to evaluate in light of the literature and other corrlations in this study, such as the mother and father scale. It appears that this correlation may be a chance error.

There are two additional reasons for caution other than this possible error. The first is the probability of a Type I error occurring due to the large number of variables in the equation. The second reason for caution is the low correlations between many pairs of variables. While these pairs achieved statistical significance, the practical usefulness of the information is limited.

In order to make a determination of practical signficance, a correlation of .33 was set as a meaningful correlation. This value was chosen since a correlation of .33 indicates ten percent shared variance. Using this cutoff off point, the following five variables achieved meaningful correlations with mathematics anxiety: test anxiety, perceptions of teacher attitudes, perceived usefulness of mathematics, confidence in one's mathematics ability, and effectance motivation in mathematics. Using this information, it appears that people experiencing higher levels of mathematics anxiety perceive mathematics as less useful, demonstrate more test anxiety, have less confidence in their mathematics ability, and perceive teachers as having more confidence in their abilities and providing more support than people with lower levels of mathematics anxiety. All of these are supported by logic and the literature, except the findings regarding perceptions of teachers, which was discussed above.

In order for the system view of mathematics anxiety to be useful, instructors and others must be able use information about the system to alter it. The variable of number of high school mathematics courses may be a statistically significant member of the system, but a student who takes additional mathematics courses may not "feel" the reduction in mathematics anxiety as it is too small to be readily noticed. So, the statistical significance has no practical importance. In this view of practical as opposed to statistical significance, there is only limited support for conceptualizing mathematics anxiety as a system comprised of all eleven independent variables. However, before discarding the hypothesis as not useful, a closer examination of the correlation matrix is warranted.

As stated in previous chapters, a system is a complex unity. Looking at the correlation matrix while keeping in mind the criteria for meaningful significance, one can see that these variables do indeed form a system. However, instead of mathematics anxiety, the focal point of the system appears to be confidence in learning mathematics. All the variables achieved meaningful as well as statistical significance with this measure. This becomes more meaningful when taking into consideration the fact that none of the other variables included in this study achieved meaningful significance with all of the other variables.

Hypothesis 2

The null hypothesis that there are no gender differences in levels of mathematics anxiety reported by men and women in this sample when controlling for number of years of high school mathematics was rejected based upon the results of an analysis of covariance. These findings indicated that women in this sample reported higher levels of mathematics anxiety than did the men even when controlling for the number of mathematics courses taken in high school.

These results are difficult to explain in light of the literature cited in Chapter II of this study (Betz, 1978; Brush, 1978; Resnick, Viehe, & Segal, 1982). As may be recalled, none of these researchers found gender differences in level of mathematics anxiety when mathematical backgrounds of the persons were similar.

One difference between the previous studies and the current one is that participants in those studies were enrolled in advanced mathematics at the time of the testing. Respondents in the present study were enrolled in a sociology course. Information regarding current enrollment in mathematics is not available. It is possible that the type of student who enrolls in a sociology course is not as likely to enroll in higher-level mathematics courses than other persons. One can only hypothesize as to what factors contribute to enrollment in the sociology course.

It is also possible that the differences are geographic, and that gender differences are more pronounced in Oklahoma than in Ohio or New York, where gender differences in mathematics anxiety were not found. This may be a valid hypothesis if the dominant culture in Oklahoma holds more traditional role expectations of women. Then mathematics would be viewed as a male domain, and women could experience higher levels of mathematics anxiety when competing in an area in which they are not expected to do well.

Hypothesis 3

Null hypothesis 3 states that the following variables do not enter a multiple regression analysis as significant predictors of mathematics anxiety: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics, 6) gender, 7) perceptions of paternal attitudes toward one as a learner of mathematics, 8) perceptions of maternal attitudes toward one as a learner of mathematics, 9) perceptions of teacher attitudes toward one as a learner of mathematics, 10) number of mathematics classes taken in high school, and 11) cognitive style. The third null hypothesis was rejected as confidence in learning mathematics, test anxiety, and effectance motivation in mathematics achieved significance in the equation.

A possible explanation as to why these three variables were the only significant predictors of mathematics anxiety is related to the concept of shared variance. This view also supports a systems view of mathematics anxiety. In this model, as the variables are interrelated, these three account for the bulk of the unique variance in the system. After they enter the equation, there is not a significant amount of unique variance between mathematics anxiety and any of the other variables to enter the equation.

There is gemeral and widespread agreement among researchers of mathematics anxiety that test anxiety and mathematical self-confidence are important contributors to mathematics anxiety. In addition, every study reported in Chapter 2 which included effectance motivation found that variable to be significantly related to mathematics anxiety. There has not been such agreement regarding all of the other variables, except mathematical preparedness. For example, there are opposing views as to the role perceived usefulness of mathematics plays in the system of mathematics anxiety (Dutton & Blum, 1968; Kincaid & Austin-Martin, 1981), and the conflicting findings regarding gender differences have been discussed at length in previous chapters.

It is still perplexing as to the reasons mathematical preparedness did not enter the equation, as there is general agreement regarding the relationship between mathematical preparedness and mathematics anxiety (Betz, 1978; Hendel, 1980). One possible explanation is related to shared variiance. The Pearson correlation matrix reorted in Table 2 indicates that mathematical preparedness is significantly correlated with all of the independent variables which were significant predictors of mathematics anxiety. It is reasonable to assume that after the three variables of mathematics confidence, test anxiety, and effectance motivation in mathemaics entered the equation, mathematical preparedness did not contribute enough unique variance to enter the solution.

Related Findings

This section of the chapter presents findings from the study which do not relate to specific hypothesis. The discussion focuses primarily on the open-ended question on the survey forms which asked respondents to relate any specific incidents which led to increased or decreased anxiety regarding mathematics. Prior to this presentation is a brief discussion of the role of cognitive style.

In order to explain the lack of significant findings regarding cognitive style, one must again look to the newly hypothesized system of mathematical self confidence. The review of the literature provided evidence that field dependence is a hinderence in mathematics (Slatterly, 1976). Persons who are primarily field-dependent, when entering situations involving mathematics could be more prone to anxiety. Perhaps the role of cognitive style in mathematics is more clearly manifested in self-confidence rather than anxiety. The answer to questions regarding the role of confidence in the system of attitudes toward mathematics must be left to later research.

The qualitative data seem to support the concept of mathematics anxiety as a system. While some of the comments may be catagorized as relating to only one of the variables hypothesized as a part of the mathematics anxiety system, many of them relate to two or more of them. The majority of the responses were negative. Negative comments included not only the requested reports of incidents, but also unsolicited comments. Before discussing the comments from the survey instrument, a mention of the unsolicited comments is in order.

During the data collection process when classes were asked to participate in a research project, there were no audible responses. When informed that the research involved attitudes toward mathematics, in three of the seven classes surveyed, there were audible groans and comments from members of the class. It is interesting to note that these responses came only after the mention of mathematics. It might be worthwhile to explore responses of students to other academic areas to determine if such audible cues would result.

As might be hypothesized from these responses, more persons related negative incidents than positive. A complete listing of the comments are found in Appendix B. Both positive and negative responses may be broken down into the three broad catagories of teacher-related, self-confidence-related and other. Although it is convenient to place comments in specific catagories for the purpose of discussion, the comments do not always fit neatly into one and only one catagory. Since it is the basis of this study that mathematics anxiety is a system of interrelated parts, this difficulty is to be expected. Recognizing that such separation may be artificial, it is still useful for conceptualization to discuss each of these catagories independently.

The largest single topic from both the positive and negative catagories was teacher-related. It is sometimes difficult to separate instruction techniques from teacher characteristics, and some of these comments reflect this difficulty. It seemed that students related the techniques to the individual teachers. Comments such as "a teacher who could explain math clearly," and "teachers who explained again and again until you understood" relate to instruction, but the implication is there that it is up to the teacher to make the effort to be clear. Other comments, such as "my teachers helped me feel comfortable with math," and "I was more comfortable taking math in HS (sic) because my teacher had a genuine concern for her students and helped in every possible way" obviously refer specifically to teachers.

As with the positive comments, many of the comments regarding negative incidents were teacher-related. "My teacher didn't explain things. Made students feel dumb" and "a teacher who didn't explain the material very will led to increased anxiety" touch on both teachers and instruction. The following quotes relate specifically to teachers: "I've never had problems with math, only math teachers," "my teacher was a jerk," and "when teachers think that students should learn it the minute they put it up on the board."

"Teachers were unwillling to help. Bitchy. Making us kids stand in front of the class and work a problem in the chalkboard by yourself. Or having math races to see who is quicker and more correct." This comment concerns both instructors and self-confidence. Other comments relating to self-confidence include "the fact that I can add sub mut dive (sic) large numbers makes me more comfortable with math," "I never believed that I could do very well in math and so I've always hated the subject," and "I find it increadibly difficult and it made me feel insecure and a little bit inferior."

Not all of the comments could be clearly distinguished as either positive or negative, as the following remark concerning self-confidence demonstrates, "Flunking Algebra I. my freshmen year in high scool made me absolutely hate it but when I took it over my senior year and made an 'A' I felt somewhat better." This individual experienced greater anxiety as a result of lowered self-confidence; however, anxiety decreased following a successful class.

Although more comments related to teachers and instruction than any other area, and there were few comments regarding paternal influences and none regarding maternal influences on levels of mathematics anxiety, this cannot be taken as evidence that family influences are not present in mathematics anxiety. Poffenberger and Norton (1956, 1959) demonstrated that social influences are an important componant in attitudes toward matheamtics. There is also the slight evidence of the relationship between perceived parental attitudes and mathematics anxiety in the correlalation coefficients caluculated in this study.

It may also be that the lack of comments regarding parental impact on attitudes is most conspicuous in its absence. That is, parents tend to ignore mathematics or excuse poor performances in classes, and so respondents did not think to remark upon their parents as contributing to confidence in or anxiety regarding mathematics.

Summary of Related Findings

These responses provide support for the notion that mathematics anxiety is a real problem. This is evidenced by the response by several of the classes to the survey as well as the preponderence of negative comments. There is also some support for the systems view of mathematics anxiety in that many of the comments refer to more than one aspect of the proposed system. Additional support for the results of the data analysis are the many remarks which deal with self-confidence. Contrary to the results of the data analysis are that the more of the comments, both positive and negative, relate to teachers or teachers and instruction than any other area.

Conclusions

Mathematics anxiety has been perceived as a barrier which may prevent students from taking a full complement of mathematics courses or successfully completing a degree pro- program. The research cited in previous chapters enumerated a large number of variables associated with mathematics anxiety. The conclusions reached regarding certain of these variables differed according to the focus of the research or other factors.

The purpose of the present study was to examine the overall structure of the system of mathematics anxiety. The general hypothesis of this study was that mathematics anxiety is a system made up of the following variables: 1) test anxiety, 2) confidence in learning mathematics, 3) perceptions of the usefulness of mathematics, 4) effectance motivation in mathematics, 5) acceptance of misconceptions about mathematics 6) gender, 7) perceptions of paternal attitudes towards one as a learner of mathematics, 8) perceptions of maternal attitudes towards one as a learner of mathematics, 9) perceptions of teacher attitudes towards one as a learner of mathematics, 10) number of mathematics courses taken in high school, and 11) cognitive style. The data analyses indicated that only the variables of confidence in learning mathmatics, test anxiety, and effectance motivation in mathatics enter a multiple regression equation as significant predictors of mathematics anxiety.

There are two primary conclusions which may be drawn from this study. The first is that mathematics anxiety is indeed part of a system of attitudes toward mathematics. The second conclusion is that this system is most appropraately labeled the mathematical self-confidence system.

The literature regarding attitudes toward mathematics is rife with references to mathematics anxiety, mathemaphobia, and other catchy phrases which reflect our infatuation with psychology. However, from the results of this study, it seems that this emphasis on anxiety is misplaced. One possible explanation as to why the focus has been placed on anxiety rather than self-confidence is the current emphasis on the medical model. If one cannot refrain from drinking, one has the disease of alcoholism; if one has an emotional reaction to mathematics, one has mathematics anxiety. This is certainly a more romantic reason than a lack of confidence.

Byrd (1982) hypothesized that mathematics anxiety is rooted in perceived threats to self-esteem, and that a lack of self-confidence in mathematics can bring about higher levels of mathematics anxiety. Support for her hypothesis may be seen in the correlation matrix reported in Table 2. All of the variables hypothesized to be related with mathematics anxiety achieved significant correlations with mathematical self-confidence.

Support for Byrd's hypothesis also comes from the multiple regression analysis. The confidence scale accounted for the greatest amount of variance in mathematics anxiety. The other variables which entered the equation, test anxiety and effectance motivation in matheamtics, accounted for less than a third of the total multiple R square in the dependent measure.

The question then becomes one of how to bolster student's self-confidence. For those students beginning school, the answers are as easy, or as hard, as many of the questions facing education today: hire dedicated and professional teachers and have them teach in model schools, with parents who will encourage their children to do well in mathematics and express expectations that the children will do so. For students beyond the third grade, who already have firmly established attitudes toward mathematics, the answer might lie in tutoring groups and relaxation training (Bander, Russell, & Zamostny, 1983).

In conclusion, there appears to be a system of attitudes toward mathematics, at the center of which is mathematical self-confidence. Future investigations in this area would do well to focus on this construct in order to assist the drive to make this nation's children competent and comfortable in mathematics.

Recommendations

The results of the data analysis suggest that the most important aspect of mathematics anxiety is one's mathematical self-confidence. If significant increases in self-confidence in mathematics can be accomplished, then it appears that signifficant decreases in mathematics anxiety may result. Clues as to how this increased self-confidence may be brought about lie in the comments by students. Teachers and effective instruction are likely the key, especially if parents can be enlisted into the instructional program.

This may appear to be a simplistic and unglamorous solution to the problem, when relaxation techniques, biofeedback, and intensive study seminars are such highly touted remedies. But the fact remains that the previously-stated remedies are just that, remedies. While it is useful to know what interventions are successful in alleviating mathematics anxiety, our primary interest should be in preventing, and not curing, the problem.

It is beyond the scope of this study to detail the specific methods by which mathematical self-concepts can be increased with a resulting decrease in mathematics anxiety. Some insights may be gleaned from again examining the comments from students as to what has increased and what has decreased levels of mathematics anxiety. These comments may provide information regarding what has helped make students more comfortable with mathematics as well as what has made them less comfortable with the subject.

Relating specifically to teachers, the comments reflect the three catagories that Woolfolk (1987) suggests are qualities of good instructors: 1) knowledgeable about the subject matter and instructional theory, 2) organized and clear, and 3) warm and enthusiastic. It is difficult to separate the comments which fit into the first and second categories as making use of instructional theory includes being organized and clear. A number of students made comments about teachers who could not explain the material, or who violated what were thought to be principles of good instruction. Regarding instruction, students wrote that important things for teachers to do are to make certain that students have the basics down before moving to higher-level concepts, relating mathematics to daily activities, remember that not all students operate at the same level or have the same mathematical background, and to make liberal use of examples.

The final catagory, teacher warmth and enthusiasm, includes such concerns as to be aware that working problems on the chalk board can be very anxiety-provoking, to have and show a great deal of patience, and to give compliments when student performance warrants them, to express enthusiasm for mathematics and show concern that all students learn the material. Other suggestions which do not fall into one of those three catagories include small classrooms and the use of mathematics labs.

One can look over this list, which should look familiar to any student of instruction, and say, "Well, everyone knows these things, but now come down to earth and give us something that is realistic." To these persons one can only reply that if there is a true desire to increase students' self-confidence, these things must be done.

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APPENDIXES

APPENDIX A

DATA COLLECTION INSTRUMENT

Thank you for agreeing to participate in this study. We are interested in collecting information regarding college students' attitudes towards mathematics. Your participation is entirely voluntary and you may withdraw from the study at any time. Your responses will be kept strictly confidential and are anonymous. The numbers at the top of the forms are there to assure that the forms can be collated if they become separated. We will make no attempt to match names with responses. Your involvement in this study will take approximately 50 minutes. You will be asked to take a timed instrument and then complete some questionnaires. If you have any questions about this study or your participation in it, please contact Ross Atkinson at 624-6820 or 377-3933. Again, thank you for your participation.

In addition to completing the attached questionnaires, we would appreciate the following information about you and your experiences with mathematics in high school. This information will assist in our study of attitudes toward mathematics.

College Major:______________________________

Estimated College GPA:______________

Gender : _____ Female _____ Male

Below please place a check beside the the math classes you took in high school and list the grade you received. If there are math class(es) not listed which you took, add the name of the course and the grade received to the sheet.

CLASS	GRADE	OTHER	GRADE
General Math	______	___________	______
Algebra I	______		
Algebra II	______	___________	______
Geometry	______		
Business Math	______	___________	______
Calculus	______		
Trigonometry	______		

In the space provided below or on the back, please write about any specific incidents which you recall which led to increased anxiety regarding mathematics, or things which you recall assisted you in feeling more comfortable with mathematics.

The items in this questionnaire refer to things and experiences that may cause fear or apprehension. For each item, place a check on the line under the column that describes how much you are frightened by it nowadays. A check under 1 means NOT AT ALL, a check under 2 means A LITTLE, 3 means A FAIR AMOUNT, 4 means MUCH, and 5 means VERY MUCH. Work quickly, but be sure to consider each item individually

	Item	1	2	3	4	5
1.	Reading and interpreting graphs and charts.	___	___	___	___	___
2.	Walking on campus and thinking about a math course.	___	___	___	___	___
3.	Reading a formula in chemistry.	___	___	___	___	___
4.	Looking through the pages in a math text.	___	___	___	___	___
5.	Taking an examination (quiz) in a math course.	___	___	___	___	___
6.	Solving a square root problem	___	___	___	___	___
7.	Listening to another student explain a math formula.	___	___	___	___	___
8.	Having to use the tables in the back of a math book.	___	___	___	___	___
9.	Picking up a math textbook to begin working on a homework assignment.	___	___	___	___	___
10.	Taking an examination (final) in a math course.	___	___	___	___	___
11.	Reading the word "statistics."	___	___	___	___	___
12.	Buying a math textbook.	___	___	___	___	___
13.	Waiting to get a math test returned in which you expected to do well.	___	___	___	___	___
14.	Being given a homework assignment of many difficult problems which is due at the next class meeting.	___	___	___	___	___
15.	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.	___	___	___	___	___
16.	Thinking about an upcoming test one day before.	___	___	___	___	___
17.	Being given a "pop" quiz in a math class.	___	___	___	___	___

	1	2	3	4	5
18. Signing up for a course in statistics.	___	___	___	___	___
19. Walking into a math class.	___	___	___	___	___
20. Starting a new chapter in a math book.	___	___	___	___	___
21. Watching a teacher work an algebraic equation on the blackboard.	___	___	___	___	___
22. Getting ready to study for a math test.	___	___	___	___	___
23. Listening to a lecture in a math class.	___	___	___	___	___
24. Being told how to interpret probability statements.	___	___	___	___	___

Read each of the following sentences and decide how you feel about it. Place a check on the line above the statement which best reflects your feelings.

1. My father thinks that mathematics is one of the most important subjects I have studied

Strongly Agree Agree Undecided Disagree Strongly Disagree

2. Mathematics is enjoyable and stimulating to me

Strongly Agree Agree Undecided Disagree Strongly Disagree

3. I am challenged by math problems I can't understand immediately

Strongly Agree Agree Undecided Disagree Strongly Disagree

4. Once I start trying to work on a math puzzle, I find it hard to stop

Strongly Agree Agree Undecided Disagree Strongly Disagree

5. My father thinks I'm the kind of person who could do well in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

6. Mathematics is of no relevance to my life

Strongly Agree Agree Undecided Disagree Strongly Disagree

7. I am sure I could do advanced work in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

8. I would rather have someone give me the solution to a difficult math problem than to have to work it out by myself

Strongly Agree Agree Undecided Disagree Strongly Disagree

9. I would talk to my math teachers about a career which uses math

Strongly Agree Agree Undecided Disagree Strongly Disagree

10. My mother thinks I need to know just a minimum amount of math

Strongly Agree Agree Undecided Disagree Strongly Disagree

11. I expect to have little use for mathematics when I get out of school

Strongly Agree Agree Undecided Disagree Strongly Disagree

12. My father thinks advanced math is a waste of time for me

Strongly Agree Agree Undecided Disagree Strongly Disagree

13. My mother thinks that mathematics is one of the most important subjects I have studied

Strongly Agree Agree Undecided Disagree Strongly Disagree

14. My father has shown no interest in whether or not I take more math courses

Strongly Agree Agree Undecided Disagree Strongly Disagree

15. I can get good grades in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

16. I'm not the type to do well in math

Strongly Agree Agree Undecided Disagree Strongly Disagree

17. Mathematics will not be important to me in my life's work

Strongly Agree Agree Undecided Disagree Strongly Disagree

18. I see mathematics as a subject I will rarely use in my daily life as an adult

Strongly Agree Agree Undecided Disagree Strongly Disagree

19. When a question is left unanswered in math class, I continue to think about it afterward

Strongly Agree Agree Undecided Disagree Strongly Disagree

20. I don't understand how some people can spend so much time on math and seem to enjoy it

Strongly Agree Agree Undecided Disagree Strongly Disagree

21. My teachers think advanced math is a waste of time for me

Strongly Agree Agree Undecided Disagree Strongly Disagree

22. I have a lot of self-confidence when it comes to math

Strongly Agree Agree Undecided Disagree Strongly Disagree

23. Getting a mathematics teacher to take me seriously has usually been a problem

Strongly Agree Agree Undecided Disagree Strongly Disagree

24. My teachers think I'm the kind of person who could do well in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

25. My father thinks I need to know just a minimum amount of math

Strongly Agree Agree Undecided Disagree Strongly Disagree

26. My math teachers would encourage me to take all the math I can

Strongly Agree Agree Undecided Disagree Strongly Disagree

27. I like math puzzles

Strongly Agree Agree Undecided Disagree Strongly Disagree

28. The challenge of math problems does not appeal to me

Strongly Agree Agree Undecided Disagree Strongly Disagree

29. My teachers would think I wasn't serious if I told them I was interested in a career in science and mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

30. I don't think I could do advanced mathematics

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

31. I'll need a firm mastery of mathematics for my future work

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

32. I have found it hard to win the respect of math teachers

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

33. My father has always been interested in my progress in mathematics

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

34. Math teachers have made me feel I have the ability to go on in mathematics

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

35. My mother has shown no interest in whether or not I take more math courses

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

36. My father wouldn't encourage me to plan a career which involves math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

37. My father thinks I'll need mathematics for what I want to do after I graduate

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

38. Math puzzles are boring

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

39. My father thinks I could be good in math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

40. I think I could handle more difficult mathematics

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

41. When it comes to anything serious I have felt ignored when talking to math teachers

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

42. Taking mathematics is a waste of time

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

43. Mathematics is a worthwhile and necessary subject

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

44. I have had a hard time getting teachers to talk seriously with me about mathematics

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

45. I will use mathematics in many ways as an adult

Strongly Agree Agree Undecided Disagree Strongly Disagree

46. My teachers have encouraged me to study more mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

47. As long as I have passed, my mother hasn't cared how how I have done in math

Strongly Agree Agree Undecided Disagree Strongly Disagree

48. Math has been my worst subject

Strongly Agree Agree Undecided Disagree Strongly Disagree

49. My mother hates to do math

Strongly Agree Agree Undecided Disagree Strongly Disagree

50. My math teachers have been interested in my progress in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

51. My father has strongly encouraged me to do well in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

52. I study mathematics because I know how useful it is

Strongly Agree Agree Undecided Disagree Strongly Disagree

53. For some reason, even though I study, math seems unusually hard for me

Strongly Agree Agree Undecided Disagree Strongly Disagree

54. I'll need mathematics for my future work

Strongly Agree Agree Undecided Disagree Strongly Disagree

55. I am sure that I can learn mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

56. My mother has always been interested in my progress in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

57. Generally I have felt secure about attempting mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

58. When a math problem arises that I can't immediately solve, I stick with it until I have the solution

Strongly Agree Agree Undecided Disagree Strongly Disagree

59. My mother thinks I'm the kind of person who could do well in mathematics

Strongly Agree Agree Undecided Disagree Strongly Disagree

60. My mother thinks I'll need mathematics for what I want to do after I graduate

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

61. As long as I have passed, my father hasn't cared how how I have done in math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

62. My mother thinks advanced math is a waste of time for me

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

63. I do as little work in math as possible

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

64. Figuring out mathematical problems does not appeal to me

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

65. I'm no good in math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

66. Knowing mathematics will help me earn a living

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

67. My mother thinks I could be good in math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

68. My mother has strongly encouraged me to do well in mathematics

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

69. Most subjects I can handle O.K., but I have a knack for flubbing up math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

70. In terms of my adult life it is not important for me to do well in mathematics in high school

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

71. My mother wouldn't encourage me to plan a career which involves math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

72. My father hates to do math

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

73. Mathematical thinking is different from the thinking required in other fields

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

74. The most important thing in doing math is to use the right formula

Strongly Agree   Agree   Undecided   Disagree   Strongly Disagree

APPENDIX B

RESPONDENT COMMENTS

COMMENTS MADE BY RESPONDENTS

- I'm comfortable with it because it comes easy to me and I understand it completely.
- I was more comfortable taking math in HS because my teacher had a genuine concern for her students and helped in every possible way.
- I felt more comfortable when I knew what was going on.
- I don't really have a special aptitude for math, but I enjoy it. I do well because I work hard.
- In geometry I had study sheets that helped.
- The teacher who taught me inspired me towards mathematics.
- I had a really good teacher for Algebra I, Algebra II, and Trigonometry. She explained things really well & I understood everything. Now, I have a student teacher who should not be teaching & I am having a lot if problems in math.
- I could have a different instructor.
- My high school was small and not very many people were enrolled in the algebra class so he gave us lots of time so that we understood what we were doing.
- I caught on fast and comprehended the basics. The abstract thoughts I can comprehend as concrete. It did not just go in one ear and out the other. I listened and understood.
- My trig. teacher made math more comfortable for me.
- It was not that I didn't want to take it in high school. It interfered with the classes that I was in. After picking up algebra I. in college I started to feel that I can handle it.
- I feel that in my cooking at home my math has helped me tremendously.

- My teachers helped me feel comfortable with math.
- Calculator! I have no math classes. Nor have I had any in 8 years.
- I had a very tough teacher for trig. & calculus in high school. Whenever this teacher would compliment me (or any student - very rare) or students in these classes would compliment me or my math, I would relax and feel more confident, for a while.
- It makes me feel more comfortable with a math class if the teacher realizes that you may not have had a lot of math in the past & doesn't take it for granted about what you already know.
- I enjoy working w/ numbers and figures.
- As long as I listened I understood.
- Teachers who explained again and again until you understood.
- I had a fairly easy time in geometry and algebra.
- Math lab helped a great deal. I may not have passed, if it was not there.
- I had after school study with my math teacher.
- It comes natural to me and I like working to find a solution.
- A teacher who could explain math clearly.
- I felt better when I knew how to do it and could relate it to something.
- Very difficult test make me more comfortable.
- When my teacher would go over each type of problem I could figure out how to do them a lot easier.
- I love the way the problem always comes out neatly (after you work for hours).
- Assistance, - teachers who had thorough understanding of math as well as ability to teach it as such; thoroughly.
- Scoring high on a test assists in making me feel more comfortable with mathematics.

- After having in depth review, one-on-one instruction.

- The fact that I can add sub mut divi (sic) large numbers makes me more comfortable with math.

- Not good explanation about it I tried, but could never get good grades in math.

- I think it all started in the third grade. My teacher was an alcoholic and to get back at the class she would give us math assignments that weren't hard but took all afternoon. We had 30 minutes to do them. They should not let those kinds of teachers teach at public schools.

- My teacher didn't explain things. Made students feel dumb.

- In algebra I. I had a teacher that had just started teaching. He was very unexperienced & nervous. He made me feel insecure about math because he was.

- I don't feel comfortable at all with math. I liked computer but it was interesting and something new. But algebra was difficult for me & turned me against math.

- Not having any background of algebra. Even the beginning algebra is hard. There is not a step by step book or anything to explain how.

- My dad yelling at me everytime I couldn't understand a problem. SOB couldn't explain math to me, yet he has taught math for 18 years in jr. high.

- I've never had problens with math, only math teachers.

- I have never done particularly well in math which has caused some anxiety and I steer away from math.

- I didn't like geometry because you would have to apply rules to everything you would have to solve.

- I have never liked math, but a freshman algebra teacher greatly discouraged me by saying he didn't care if we learned it we didn't need it anyway.

- I don't like it because it takes up so much time and then it's not the right answer.

- I could love math except I need a good teacher.

- I hated to go to the board and write problems. I was scared to death.

. Anxieties: Teachers never fully explained to my full understanding.

. I never believed that I could do very well in math and so I've always hated the subject.

. When I began the 4th grade the system of teaching math was changed to what was called "modern math." I was sick for two weeks and after that my grades went from A to C.

. Math has always been a struggle.

. When the problem was in words rather than numbers and I had a hard time figuring out the equation.

. I was placed in accelerated math courses throughout high school. I think that I would have felt less pressure had I not been in a class of 20 from a graduating class of 375.

. All of the damn formulas and theorems made me hate math.

. I find it increasingly difficult and it maked me feel insecure and a little bit inferior.

. 1. tests 2. large numbers 3. abstract ideas 4. use of math in future - why do I need to learn this? When will I ever use it?

. I had a certain math teacher in high school who really couldn't relate to kids, therefore he wasn't a good teacher (in my opinion).

. I had a very tough teacher for trig & calculus in high school who would sewnd groups of students or single students to the board and make them stand there until they finished the problem. Everyone had a lot of anxiety regarding this.

. In the 11th grade I had a math class in which the instructor didn't care to teach. He failed 80% of the class, the only class in my life I failed, I made it up in summer school.

. Dealing w/ things I can't apply to my future or present life give me a real hard time learning.

. My dad would not let me use my car w/o above a 3.5.

. I loved mathematics until I took my first calculus class in college.

- Flunking Algebra I my freshman year in high school made me absolutely hate it but when I took it over my senior year & made an A I felt somewhat better.

- I was point .02 away from a B in geometry and the teacher would not give it to me, In the teachers words "There is no room in math for not being precise."

- None, I hate math.

- Trying to grasp calculus.

- It's boring.

- Didn't understand some parts & that made me uncomfortable in situations I had to use it.

- I hated using all of those properties and letters in algebra I.

- Math 2365 caused anxiety.

- Bad explanation - bad teacher - not understanding, sitting down & being scared that I cannot do the work - feeling stupid.

- Geometry was the only math class I had trouble with. I couldn't remember all of the postulates and theorems because there were too many.

- In elementary school, our math program was done on a "work at your own pace" basis. We were assigned packets that listed several assignments to complete, and when we were finished, we were tested over the material. So every student could be working on a completely different kind of math, and the teacher would have quite a hard time trying to help all of us (there were 20-30 kids per class). I went to this school for 6 years, had trouble in math every year, and never got the help I needed. To this day, math is my worst subject.

- Teachers were unwilling to help. Bitchy. Making us kids stand in front of the class and work a problem on the chalkboard by yourself. Or having math races to see who is quicker and more correct.

- I had a very difficult time in Algebra (8th grade) bcause I missed an entire week of scool and could not catch up well. I also am not very accurate with numbers, but I do grasp concepts fairly easily. I am not comfortable with numbers; I prefer to work with letters.

- I was placed in the advanced math class in the sixth grade, with all the "smart" people. This, coupled with two "evil" teachers in the 6th and 7th grades has given me a bad attitude.

- I do poorly in math because I don't pay attention, then panic & blank on the tests.

- Tests - geometry.

- I hated theorems in geometry. I hated trying to prove them.

- My teacher was a jerk.

- Teachers didn't seem willing to answer questions. Went too fast, also.

- When something new was introduced I got losted (sic), I did not see the application till after the course. I used algebra more after the class than in or before it.

- There was not enough time to get comfortable with the material so it added to my test "phobia." I would feel nervous up to a day before the test. Normally it hits about two hours before other tests.

- Being tested during a timed test. Racing on the chalk board.

- Changing schools in the 7th grade. Being placed in an unfamiliar higher math class.

- No experience.

- A teacher who didn't explain the material very well led to increased anxiety.

- I dropped math this semester and I want to wait until spring to take it.

- Numbers confuse me.

- The math instructor that I had in high school thought he knew everything there was to know about math. He only gave his attention to those stuents who did very well. He taught one chapter per day, took a few minutes for questions the next day and went on to the next chapter. In math, at least in my experiences, it takes repitition to learn. You cannot be expected to learn math in one day (unless you are "gifted" in math).

- A few bad grades and a couple worthless teachers increased my anxiety.
- When teachers think that students should learn it the minute they put it up on the board.
- When you try & try to work a problem and can't get the correct amswer.
- The time allowed to take the test.
- Because I want to go into the electronics field and you have to take a lot of math.

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VITA

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Doctor of Philosophy

Thesis: AN EXPLORATION OF THE FACTORS RELATING TO THE SYSTEM OF MATHEMATICS ANXIETY

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