RELATIONSHIP BETWEEN MATHEMATICS ANXIETY AND ACHIEVEMENT IN MATHEMATICS: A META-ANALYSIS

by

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ABSTRACT

This thesis investigated the findings of studies on the relationship between mathematics anxiety and mathematics achievement for elementary and secondary school students using meta-analysis.

Twenty five studies which met a selection process established for this research, and 47 effect sizes representing 22 189 students, were analyzed.

The results of the study indicated that there is a negative relationship between mathematics anxiety and mathematics achievement in the elementary and secondary school. Three homogeneous groups were identified with correlations -0.20, -0.32, and -0.43 respectively. However, there was no enough information to find out whether each of the group correlations were in the optimal arousal curve.

Results were found to indicate that this negative relationship holds across grade level and appears to get stronger from primary to secondary school.

Analysis of the studies indicated that there were no statistically significant differences in the mathematics anxiety-achievement relationship across gender. The average correlation for males was -0.26 and -0.25 for females.

The study also found that the mathematics anxiety-mathematics achievement varies across ethnicity. For example the average correlation for Asian students was -0.14 and -0.32 for mixed (USA) students.

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Chapter I: Introduction

The National Council of Teachers of Mathematics (NCTM) (1989) stresses that learning mathematics "includes developing a disposition toward mathematics. . . . Disposition refers not simply to attitudes but to a tendency to think and to act in positive ways" (p. 233). This extract from the NCTM's Curriculum and Evaluation Standards for School Mathematics reflects the widespread belief among mathematics educators and educational psychologists in the importance of the development of students' positive attitudes toward learning mathematics. Implicit in such suggestions is the belief that the affective domain plays an important role in learning and teaching of mathematics (Aiken, 1970, 1976; Kulm, 1980; Mcleod, 1992, 1994).

An important affective factor that educators give attention to, for its potential influence on learning and achievement, is students' anxiety toward mathematics (Leder, 1987; Mandler, 1989; Mcleod, 1992; Reyes, 1980, 1984). Mathematics anxiety has been defined as "the general lack of comfort that someone might experience when required to perform mathematically" (Wood, 1988, p. 11). Williams (1988) referred to the same problem as "both an emotional and a cognitive dread of mathematics" (p. 96).

Donady and Tobias (1977) suggested that many students do suffer mathematics anxiety and, as a result, they do not engage in mathematics activities and try to avoid encounters with mathematics. Resek and Rupley (1980) reported that many university students "are quite talented in their own fields (e.g., areas of social sciences), but due to poor experiences in past mathematics classes they have developed mathophobia and consequently have poor arithmetic skills" (p. 423). Futhermore, several studies suggest that mathematics anxiety is prevalent among students, and influences critical areas such as mathematics learning, mathematics achievement, enrollment in mathematics courses and subsequently, choices of college major and career (Betz, 1978; Brush, 1978; Hendel, 1980; Preston, 1987; Tobias & Weissbrod, 1980).

For the mathematically anxious student, confrontations with mathematics are remembered as a threat to the ego and as a noncreative, rigid experience (Tobias & Knight, 1978). According to Burton (1979), many children and adults are victims of these experiences which seem to be contagious and far-reaching in their consequences. This perception of helplessness, and the guilt and shame associated with it, may account in part for the debilitating condition called "mathematics anxiety" (Burton, 1979).

Mathematics has served as a vocational filter; people who avoid mathematics early in their careers have their options severely limited (NCTM, 1991; Sells, 1978; Perl, 1982; Tobias & Knight, 1978). Careers that were comfortably free of mathematics in the 1960s are, in the 1990s, more dependent than ever upon mathematics knowledge (NCTM, 1991). Administrators frequently depend to a great extent on mathematical models, elaborate accounting systems, and computerized data analysis (NCTM, 1989, 1991). The professional and economic advantage individuals gain in changing their mathematics anxiety into mathematics confidence is important, but the psychological boost they experience when they are able to succeed is just as important (National Research Council, 1989).

Mathematics anxiety is believed to affect the extent to which a student pursues any more than minimal requirements in mathematics, and the extent to which the student is able to learn mathematics, perform mathematics skills and understand mathematics concepts (Richardson & Suinn, 1972). Betz (1978) stated that mathematics anxiety is an important factor in a student's educational and vocational decisions and could, in addition, influence the student's achievement.

Lazarus (1974) noted that mathematics anxiety could arise at any point during an individual's school experience, and that the phenomenon is unlikely to disappear on its own without intervention. Children with mathematics anxiety are troubled with mathematics throughout their school and vocational careers (Lazarus, 1974). The specific causes of mathematics anxiety are difficult to recognize and their effects may not be detected at the beginning (Gough, 1954). According to Betz (1978), Richardson and Woolfolk (1980), and Sells (1980) little is known about the prevalence and effects of mathematics anxiety that is associated with a lack of formal education in the subject. Educators need to identify the factors that affect the formation of unfavorable mathematics attitudes. They need to recognize immediately those students who meet frustrations which can cause mathematics anxiety, and initiate the use of corrective methods to remediate and lessen the effect of these school experiences (McMillan, 1976).

Recognition of mathematics anxiety during its development in the school could have an impact on preventing long term effects. This early awareness could lead to the discovery of related factors and implementation of effective ways of dealing with mathematics anxiety (Betz, 1978; Lazarus, 1974; McMillan, 1976). Such information could offer valuable guidelines for program and staff development efforts in this problematic area.

A great deal of research has been directed at the issue of mathematics anxiety (McLeod, 1992, 1994), but most of these studies have been concentrated on college students and other adults, with no attention at the elementary and secondary levels. Even when the research was done with adults the results indicated that mathematics anxiety often originated during early educational experiences (Chiu & Henry, 1990). In the opinion of this researcher more studies with younger children are needed as teachers need to become more aware of students' anxiety toward mathematics and how they can help students to deal with it. Further, literature reviews have been done on mathematics attitudes but not specifically on children's mathematics anxiety. Because of the number of studies in the body of literature on mathematics anxiety, the lack of reviews on the topic of mathematics anxiety and mathematics achievement, and the lack of priority given to younger children, this study is designed to bring a degree of synthesis to the past findings in the relationship between mathematics anxiety and mathematics achievement in elementary and secondary school students.

Statement of the problem

The aim of this study is to provide a synthesis of research findings on mathematics anxiety in elementary and secondary schools, regarding its nature and effect on mathematics achievement. This study will explore and integrate the findings on the relationship between mathematics anxiety and mathematics achievement using meta-analysis. Futher, the analysis of the mathematics anxiety-mathematics achievement relationship will include the extent to which it varies across the variables of grade level, gender, and ethnicity.

Significance of the Problem

Based on the large number of studies, dissertations, published reports of conference proceedings, and published documents dealing with anxiety towards mathematics, McLeod (1992) concluded that the topic "has probably received more attention than any other area that lies within the affective domain" (p. 584). McLeod (1994) wrote that "an area of major and related interest to research on attitudes is the substantial amount of work that has been done on mathematics anxiety" (p. 639).

In the opinion of this researcher, educators need to go beyond the accumulation of new studies which attempt to examine similar issues. The point has been reached where a synthesis of findings and results is needed to determine common trends and patterns, and to figure out what should be researched in the future. Glass (1976) pointed out:

> In educational research, we need more scholarly effort concentrated on the problem of finding the knowledge that lies untapped in completed research studies. We are too heavily invested in pedestrian reviewing where verbal synopses of studies are strung out in dizzying lists. The best minds are needed to integrate the staggering number of individual studies. This endeavor deserves higher priority now than adding a new experiment or survey to the pile. (p.4)

Some literature reviews have been conducted in the area of mathematics attitudes with no attention to mathematics anxiety (Leder, 1987; McLeod, 1992; Reyes, 1980, 1984). Further, no statistical analyses of the data were performed in these reviews. Some statistical analysis of the data might reveal relationships and help identify variables that may provide insight in developing explanations of the reported results.

This study is being carried out because of its perceived significance and its potential contribution to the field of mathematics education. It is hoped that the study will enhance the existing literature on mathematics anxiety by identifying variables that can serve as guidelines to clarify the relationship between mathematics anxiety and achievement at the elementary and secondary school levels. This study will also provide a basis for recommendations concerning the conditions that should be controlled and some of the variables that should be measured in future studies of mathematics anxiety and achievement.

In this study, not only is a review of the pertinent literature given, but several statistical analyses of the data were performed. These analyses and the review should be helpful to mathematics educators and educational researchers who are attempting to make an assessment of the impact of mathematics anxiety on the learning and teaching of mathematics.

Research Questions

The primary purpose of this study is to analyze the available research on the relationship between mathematics anxiety and mathematics achievement from elementary through secondary school, by means of meta-analytic procedures (Hedges & Olkin, 1985; Rosenthal, 1991). A secondary purpose of this study is to examine the extent to which the mathematics anxiety-achievement relationship varies across grade level, gender, and ethnicity. Taking into consideration that these studies are expected to produce varied results, the investigation will be guided by a main research question followed by other questions. The statistical analyses for these research questions are discussed in Chapter III in the section on data analysis.

Main Research Question. What is the magnitude of the relationship between mathematics anxiety and mathematics achievement for elementary and secondary school students, using the correlation coefficient r as a common metric?

For purposes of analysis. the main research question was broken down into the following questions:

Question 2. To what extent does the mathematics anxiety-achievement relationship vary across grade level ?

Question 3. To what extent does the mathematics anxiety-achievement relationship vary across gender ?

Question 4. To what extent does the mathematics anxiety-achievement relationship vary across ethnicity ?

Operational Definitions

The following definitions are offered to clarify the meaning of important terms used in the study:

Dependent Variables: The dependent variables are the effect sizes measured by the correlation coefficients between mathematics anxiety and mathematics achievement outcomes in the individual studies.

Independent Variables: The independent variables are the study features related to the research questions and extracted from the individual studies.

Mathematics Achievement: Scores on tests in mathematics whether teacher made, textbook, or standardized that are reported in the studies.

Mathematics Anxiety: Scores on tests of anxiety toward mathematics measured by validated instruments that are reported in the studies.

Meta-Analysis: The statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings (Glass, 1976).

Unit of Analysis: The correlation outcomes of the individual research studies selected for the meta-analysis.

Limitation

There is one main factor which imposed a limitation on the present study. The limiting factor concerns the availability of the necessary statistics in the studies for conducting a meta-analysis. Some studies neither provided the correlation coefficients between mathematics anxiety and achievement nor sufficient information for its calculation. This led to the rejection of these studies in the analysis.

Delimitations

The delimitations of the study are related to decisions that are made concerning the final selection of the studies to be included in the analysis of the data.

During the beginning phases of the study, published and unpublished research studies containing the desired descriptors- mathematics anxiety, mathematics achievement and mathematics performance-were examined. However, not all of these studies could be retained for the analysis because they could not meet the criteria listed below. These were:

1. Providing data on mathematics anxiety and mathematics achievement from elementary or secondary school classroom settings.
2. Using validated instrument to measure mathematics anxiety.
3. Reporting the product-moment correlation coeffient r, or sufficient information for its calculation.

These three criteria are discussed in more detail in Chapter III. The discussion in Chapter III also describes characteristics of some of the studies which were eliminated from the analysis because of failure to meet these criteria.

Organization of the Thesis

The study is presented in a thesis of five chapters.

Chapter I presents the general rationale of the study with pertinent information to support the significance of the study. The chapter includes an introduction, statement of the problem, significance of the problem, research questions, operational definitions, limitations, delimitations, and organization of the thesis.

Chapter II summarizes the literature related to the study. The literature review is presented in six main sections: nature of mathematics anxiety, measurement of mathematics anxiety, previous reviews, gender and mathematics anxiety, ethnicity and mathematics anxiety, and mathematics anxiety and achievement.

Chapter III is devoted to a detailed description of the procedures to be followed in applying the criteria for including studies, locating the studies, coding study features and quantifying study outcomes. The procedures used in the data analysis are also described.

Chapter IV presents the data. The analysis of the data and interpretation of the findings are also presented in this chapter.

Chapter V contains a summary of the study, the conclusions, and suggestions for further research.

Chapter II. Review of Literature

Introduction

The primary concern of this study is the analysis of existing research on the relationship between mathematics anxiety and mathematics achievement. This chapter is a review of the literature and research findings in the area of mathematics anxiety. The first section describes the nature of mathematics anxiety. The second section refers to the measurement of mathematics anxiety. The third section in this chapter reports on previous reviews. The fourth section deals with gender differences in mathematics anxiety. The fifth section reported on some studies that dealt with ethnicity. The sixth section summarizes findings on mathematics anxiety and achievement in mathematics.

Nature of Mathematics Anxiety

Anxiety, in general, is a state of apprehension felt by a person. In Webster's Ninth New Collegiate Dictionary (1985) anxiety is defined as a "painful or apprehensive uneasiness of mind usually over an impending or anticipated ill" (p. 93). It is not uncommon to liken this apprehension to fear. In many instances fear and anxiety are used interchangeably. However, there is a distinction that can be made between the two: fear is often defined as a response to a definite and specific threat or danger, while anxiety is a fear of something unknown or indefinite. One can be anxious and not know why but one cannot be afraid and not know the cause of the fear (Ohman, 1993).

Anxiety, as defined in psychological literature, typically refers to a heightened state of arousal that produces feelings of discomfort, excessive concern or worry. Arousal is a condition, varying in intensity and mediated by the sympathetic nervous system, in which changes in bodily processes prepare an individual to respond to a perceived demand for action (Gatchel & Baum, 1983; Bandura & Adams, 1977).

In the traditional arousal theory originated by Hebb (1955) the fundamental idea is that there is an optimal level of arousal and that this is somewhere around the middle of the arousal dimension. This idea can be represented graphically by an inverted-U curve shown in Figure 2.1. "Optimal" means both optimal in terms of achievement and optimal in the sense of hedonic tone (most pleasent).

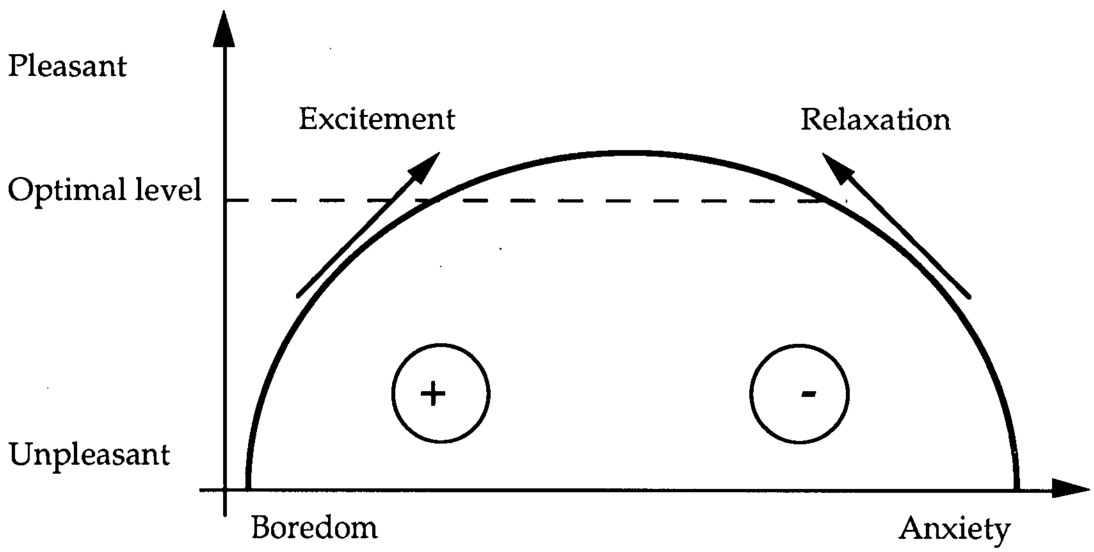

Figure 2.1 The relationship between arousal and hedonic tone according to optimal arousal theory (Hebb, 1955).

Spielberger (1972) has distinguished between two aspects of anxiety. State anxiety (A-State) is "a transitory emotional state" (p. 39) of tension and nervous reaction, whereas Trait anxiety (A- Trait) is a chronic anxiety proneness characterized by A-State reactions in a wide range of stimulus situations. According to Spielberger, Anton, and Bedell (1976) trait-state theory, test anxiety is a form of trait anxiety. High-anxious people respond to testing with elevations in A-State (or emotionality); worry is then triggered by the A-State manifestations. These latter reactions also activate random error tendencies. Hence, emotionality and worry both contribute to depressed performance (Spielberger, Anton, & Bedell, 1976).

Mathematics anxiety is described by Richardson and Woolfolk (1980) as different from test anxiety. Mathematics anxiety is a reaction to mathematical content, to some of its distinctive features as an intellectual activity and its connotative meanings for many people in our society, as well as reaction to evaluative forms of mathematical tests and problem-solving activities. It is a reaction not only to the testing of content but to the precise nature, the language and symbols and the apparent uselessness of some mathematics taught in schools (Richardson & Woolfolk, 1980).

Richardson and Suinn (1972) found that mathematics anxiety exists among people who did not ordinarily suffer from any other tensions. They also showed that mathematics anxiety, although related to general anxiety, was different because many people who were not generally anxious were anxious about mathematics.

Wood (1988) has defined mathematics anxiety as "the general lack of comfort that someone might experience when required to perform mathematically" (p. 11). Williams (1988) referred to the same problem as "both an emotional and a cognitive dread of mathematics" (p. 96).

Mathematics anxiety and mathematics avoidance were unnoticed outside of the field of mathematics for many years. Traditional beliefs were that people were born with mathematical ability or they were not.

From this belief came the idea that there was no need to try to help those who did not possess the necessary ability (Tobias & Knight, 1978).

Bush (1991), and Sepie and Keeling (1979) suggest that mathematics anxiety begins to appear at about the age of entry to secondary school but sometimes even in the lower grades. Futhermore, limited participation in mathematics courses at the secondary level has been blamed at least in part on the lack of confidence due to mathematics anxiety that has its roots in the elementary school experience (Fennema and Sherman, 1976; Frary & Ling, 1983; Reyes, 1984).

Buhlman and Young (1982) affirm that mathematics anxiety is as prevalent among elementary teachers as among the general public. According to Giordano (1991) if teachers have negative feelings towards a subject they are teaching, such feelings "might be inadvertently passed to students" (p. 43).

In the literature it is difficult to separate research on anxieties towards mathematics from research on beliefs about mathematics. For example, Kloosterman and Clapp-Cougan (1991) interviewed students from grade one to six. These researchers designed an instrument which included questions about students' attitudes towards school, their perceptions of mathematics, and their perceptions of themselves as mathematics learners. They state, "the children we interviewed indicated that grades and teacher feedback about the correctness of their assignments rather than conceptual understanding was the basis for their level of self-confidence in mathematics. In addition, by fourth grade, students began to note that they were better at some types of mathematical tasks than others" (p. 7). The researcher concluded: "Overall, we found that a majority but certainly not all students liked school and mathematics. Only a few liked school more than they liked mathematics and almost none liked mathematics substantially more than they liked school in general" (p.7). Lazarus (1974) and Tobias (1978) claim that a discomfort with mathematics is acquired early in the school and can develop into a syndrome of anxiety and avoidance of mathematics.

McMillan (1976) claims that mathematics anxiety arises from an affective climate in which negative attitudes and anxiety are transmitted from adults to students. McMillan (1976) suggests that "the factors which have an impact on student attitude development toward school subjects reside with the teacher and student and not with the curriculum or instructional approach" (p. 325). More specifically, Bulmahn and Young (1982), Kelly and Towhave (1985), and Lazarus (1974) in addition to Giordano (1991), cited earlier, suggest that teachers with mathematics anxiety transmit their anxiety to their students. Lazarus (1974) and Wilhelm and Brooks (1980) added that negative parental attitudes may be transmitted to their children and that parents often reinforce their children's mathematics anxiety. On the other hand, others (Bush, 1989, 1991; Becker, 1986) argue that negative attitudes of teachers do not tend to induce mathematics anxiety in their students; others argue that elementary teachers have generally positive attitudes, even though they had developed some negative attitudes toward mathematics when they were students (Widmer and Chavez, 1982).

In summary, research findings in mathematics anxiety are inconclusive, but some results seem to suggest that mathematics anxiety begins during early educational experiences in the school or at home.

Measurement of Mathematics Anxiety

A limited number of instruments, mainly Likert-type inventories, have been developed for the measurement of mathematics anxiety of secondary school students or adults. Dreger and Aiken (1957) have developed a "number anxiety" scale for use with eighth, ninth, and tenth grade students (Adwere-Boamah, Muller, & Kahn, 1986; Dreger & Aiken, 1957).

Richardson and Suinn (1972) developed the first comprehensive scale designed specifically to measure mathematics anxiety and validated it first with adults. The Mathematics Anxiety Rating Scale (MARS) consists of a total of 98 items describing situations that could arouse mathematics anxiety. Respondents indicate how much they are affected by the situation described by selecting one of the following options: not at all, a little, a fair amount, much, and very much. Some items arouse very little anxiety while others could arouse a lot. The MARS was compared to some other measures of anxiety for validity, the resulting Pearson product-moment correlations were 0.68 with measures of social anxiety, 0.80 with the Taylor Manifest Anxiety Scale, and 0.78 with the Test Anxiety Scale (Suinn, Edie, Nicoletti & Spinelli, 1972)

Since both the shortened (Plake & Spark, 1982) and original versions of the MARS were designed for college students, the Mathematics Anxiety Scale for Children (MASC) was developed by Chiu and Henry (1990) "to be used in the upper elementary grades and middle schools" (p. 23).

The twelve item Fennema-Sherman Mathematics Anxiety Scale (MAS), initially designed for use with high school students, has subsequently been employed with adults (Fennema & Sherman, 1976;

Llabre & Suarez, 1985; Wikoff & Buchalter, 1986). Sandman (1974) developed the 6-item Mathematics Attitude Inventory (MAI), initially used with students in the eighth to eleventh grades, but considered appropriate for adults. Comparative reliability, and validity data have been reported for the last three scales, for example the MAS is correlated with the MARS (r=0.68) and with the MAI (r=0.78) (Dew, Galassi, & Galassi, 1983, 1984). According to Cohen (1977) who consider r = 0.50 large these correlations are very high.

The MARS Adolescent Form (MARS-A) has been used with junior high and senior high students (Battista, 1986; Holden, 1987; Lindbeck & Dambrot, 1986; Rounds and Hendel, 1980; Saigh & Khouri, 1983; Suinn, Edie, Nicoletti, & Spinelly, 1972; Suinn & Edwards, 1982). Suinn also developed an instrument for assessing mathematics anxiety at the elementary level: the Suinn Mathematics Anxiety Rating Scale, Elementary Form (MARS-E) used with fourth, fifth, and sixth grade students (Suinn, Taylor, & Edwards, 1988).

In summary, there is a lack of instruments to measure mathematics anxiety in children in the lower elementary grades, and the tests originally developed for secondary school students have been mainly used with adults.

Previous Reviews

Some narrative literature reviews have been conducted in the area of mathematics attitudes with little attention given to mathematics anxiety (Aiken, 1970, 1976; Neale, 1969; McMillan, 1976; Robinson, 1975). By reviewing 124 dissertations, McMillan (1976) reports that teachers' attitudes and enthusiasm toward a subject had greater impact on student attitudes "regardless of the curriculum materials" (p. 325). Neale (1969) concluded that the relationship between attitudes toward mathematics and achievement in mathematics was not strong and had correlation coefficients between 0.20 to 0.40. Robinson (1975) argues that this relationship is not significant and has no useful implications for educational practice. Aiken (1970) however found that this relationship is statistically significant but not large for elementary schools. Aiken (1976) also reports that the correlations through elementary, secondary, and college levels were usually low and positive, but did not always reach the level of statistical significance.

There have been some reviews in the area of self-concept/motivation in mathematics (Hansford & Hattie, 1982; Uguroglu & Walberg, 1979). A meta-analysis by Hansford and Hattie (1982) and a quantitative synthesis by Uguroglu and Walberg (1979) report that the relationship between self-concept in mathematics and mathematics achievement is significant and positive.

There have also been narrative reviews about the importance of the affective domain in general, including mathematics anxiety, in the learning and teaching of mathematics (Leder, 1987; Macleod, 1992; Reyes, 1980; 1984). Hunt (1985) provides an overview of the literature related to mathematics anxiety, concluding that society needs to eradicate the myth that females are more anxious about mathematics than males. Wood (1988) gives a general overview of the problem of mathematics anxiety in elementary teachers at both the preservice and the inservice levels, assuming that teacher's mathematics anxiety influences students. These reviews used the traditional method of narrative literature review, they do not deal mainly with elementary or secondary school children, and no statistical analyses of the data were performed. Hembree's (1990) study is the only meta-analysis found in the research concerning the relationship between mathematics anxiety and mathematics achievement. He found the average correlation for grades 5 to 12 (with 7 studies) to be -0.34 and -0.31 for college students (with 58 studies). Although he concludes that mathematics anxiety is related to low achievement in mathematics, the in-proportionate number of studies with college students must be kept in mind.

In summary, there have been some narrative reviews in the area of self-concept in mathematics, or in attitudes toward mathematics. But no emphasis is given to mathematics anxiety. These reviews dealt mainly with adults. Only one meta-analysis was found that dealt with younger children.

Gender and Mathematics Anxiety

Some researchers have claimed that mathematics anxiety is gender-related. Wigfield and Meece (1988) reported that among elementary and secondary school-aged children, girls had stronger and more frequent negative affective reactions to mathematics than boys. A study by Eccles and Jacobs (1986) with students in the seventh, eight, and ninth grades suggest that "math [sic] anxiety appears to be a key social/attitudinal variable that might account for sex differences in achievement and enrollment in mathematics courses" (p. 375).

Mathematics anxiety occurs among college students and was also found to be more prevalent among college women than among college men (Ashcraft & Faust, 1994; Bander & Betz, 1981; Betz, 1978; Brush, 1985). However, when Richardson and Suinn (1972) validated the MARS they found no gender differences with their sample of 397 university students. Frary and Ling (1983) in a study with 491 non-technical majors university students suggest that while higher levels of mathematics anxiety are related to lower mathematics achievement, there are not necessarily gender differences in mathematics anxiety. Others have stated that it is the amount of experience with mathematics, not gender, that is predictive of mathematics anxiety in college students, and they maintain that females typically take fewer mathematics courses in high school than males (Llabre & Suares, 1985; Richardson & Woolfolk, 1980).

A study with university students by Hunsley and Flessati (1988) found that the more anxious subjects reported the most negative experiences with mathematics, regardless of whether they were female or male. On the other hand, females scored significantly higher than males in mathematics anxiety, while at the same time failing to report less favorable experiences with mathematics. Hunsley and Flessati (1988) suggest that males, compared to females, may be less likely to admit to being mathematics anxious, and may report less mathematics anxiety than they actually experience. Referring to this study, Flessati and Jamieson (1991) indicate that a response bias explanation cannot account for the gender difference in mathematics anxiety, but the fact that "females are more self-critical of math [sic] anxiety in themselves, and are more self-critical of their performance in math [sic] could explain the gender difference in mathematics anxiety" (p. 311). They added that more research is needed in this area.

In Hembree's (1990) meta-analysis, with respect to mathematics anxiety "females displayed higher levels than males, especially in college"

(p. 40) with average effects differentials of 0.19 in precollege and 0.31 in college.

In summary, most of the studies that dealt with gender and mathematics anxiety have been at the college level. Some studies suggest females tend to report higher levels of mathematics anxiety which is inversely correlated to the low number of mathematics courses they have taken. Other studies suggest that mathematics anxiety in females is related to their underestimation of their ability in mathematics.

Ethnicity and Mathematics Anxiety

Some studies have been done in the area of ethnicity and mathematics achievement. However, research in the area of ethnicity and mathematics anxiety is very little. For example, a study by Corbbit (1981) indicates that mathematics achievement average for black and Hispanic college students are significantly below that of the general average in the USA. The study, also, found that although black students have a positive attitude toward mathematics, they actually took fewer courses (Corbitt, 1981).

Campbell (1986) found that black and Hispanic college students in the USA take fewer mathematics and science courses and are clustered at the lower achievement levels. "Controlling for the number of math [sic] courses taken does not eliminate ethnic and sex differences in mathematics achievement but it does significantly reduce them" (Campbell, 1986, p. 516).

Knox (1985) found that black and Hispanic college students in the USA take fewer algebra and geometry courses than white students and are enrolled in fewer advanced and honors mathematics courses. She also noted that minorities are heavily concentrated in low-income areas with school districts where the level of learning mathematics and science is the lowest.

Muinos (1988), in a study with university students found that black and Hispanic students do not score higher than whites in mathematics anxiety, yet achieve at lower levels in mathematics because they "do not have the level of anxiety that provides the motivation needed to succesfully complete a mathematics course, or to complete it at high level", and he added that "parental and cultural influences may be such that minorities are not supported and encouraged to excel when it comes to the study of mathematics" (Muinos, 1988, pp. 73-74).

In Hembree's (1990) meta-analysis, the studies describing ethnic effects were limited to college students, and no difference appeared between white and black college students with respect to mathematics anxiety in five studies, with comparison values ranging from -0.33 to 0.30. He also reported that Hispanic college students seemed more anxious than the other two ethnic groups in two studies, with comparison values ranging from 0.82 to 0.83. Correlations between mathematics anxiety and mathematics achievement from these ethnic groups were not reported.

In summary, there are a few studies that deal with ethnicity and mathematics anxiety, and those available have been at the college level, with black, Hispanic and white students in the USA.

Mathematics Anxiety and Achievement

The relationship of mathematics anxiety to achievement in mathematics is sometimes difficult to demonstrate (Gliner, 1987; Mevarech and Ben-Artzi, 1987). Quilter and Harper (1988) found mathematics anxiety to be negatively correlated to mathematics performance in the adult population. Some studies have found that children who were "under-achieving" in mathematics were significantly more mathematics anxious than other children (Sepie and Keeling, 1979); others have found a positive significant relationship between mathematics anxiety and mathematics achievement (Bush, 1991), while others argue that the nature and direction of this relationship is not completely clear (Reyes, 1984).

Boodt (1979) tested relationships between mathematics achievement and mathematics anxiety for college age students, and no significant correlations were indicated. Betz (1978) showed that mathematics anxiety did occur among college students in general, and was moderately related to mathematics achievement. He recommended further study to locate the genesis of mathematics anxiety, methods of treatment, and means for improving achievement. Frary and Ling (1983) suggest that higher levels of mathematics anxiety are related to lower mathematics achievement among university students.

Fennema and Sherman (1977); Hendel (1980); Rounds and Hendel (1980); Wigfield and Meece (1988) found in sixth through twelveth grade children that knowledge of a student's level of mathematics anxiety contributed substantially to the prediction of mathematics performance. Conversely, Resnick, Viehe, and Segal (1982) found that knowledge of a subject's level of mathematics anxiety led to no improvement in prediction of subject's performance scores. However, since the sample in the latter study consisted entirely of college students with extensive backgrounds in mathematics it is possible that the range of mathematics anxiety was limited.

Hembree (1990) found that levels of mathematics anxiety increased through junior high school, peaked at grades nine and ten, and then leveled off for the last years of high school and college. He found for grades five through twelve, higher levels of mathematics anxiety related to lower achievement in mathematics. Hembree (1990) suggested that mathematics anxiety may depress achievement on mathematical tasks, and points out that reduction in mathematics anxiety consistently leads to higher levels of achievement in mathematics. He also found that highly anxious students took fewer mathematics courses in high school and rarely expressed plans to pursue a mathematics, or science-related career in college. In contrast, Bush (1991) in his study of fourth, fifth and sixth grade students found a positive significant relationship between mathematics anxiety and achievement in mathematics, and argues that mathematics anxiety tends to rise in students whose mathematics performance increased.

In summary, the general trends suggest that there is a negative correlation between mathematics anxiety and achievement at the college or university level.

Summary

The purpose of this chapter was to review the literature related to the relationship between mathematics anxiety and mathematics achievement. The first section reported on the nature of mathematics anxiety. Most of the research results with adults suggest that students' mathematics anxiety originates during early educational experiences, and is influenced by teachers' and parents' negative attitudes towards mathematics.

The second section concerned to the measurement of mathematics anxiety. The majority of the instruments have been developed initially for secondary school students, but they have been mainly used with adults.

The third section reported on previous reviews. Most of the reviews have been narrative and on affective factors particularly on attitudes toward mathematics, with little attention to mathematics anxiety.

The fourth section dealt with gender differences in anxiety towards mathematics. The majority of the studies suggest that when gender differences do occur, higher levels of mathematics anxiety are reported for females, especially in college.

The fifth section reported on some studies that dealt with ethnicity. Some studies found that black and Hispanic college students do not report higher levels of mathematics anxiety, yet they achieve at lower levels in mathematics than white students.

The sixth and final section reported on mathematics anxiety and achievement in mathematics. Most of the studies support the conjecture that mathematics anxiety is negatively related to achievement in mathematics at the college or university level.

All six areas point out that most of the studies in mathematics anxiety are not based on statistics tests, and are based on college or adult students. There is little research on mathematics anxiety with primary school children, yet the studies done with college students or adults suggest that many times mathematics anxiety originated during early educational experience.

Chapter III: Methods and Procedures

Introduction

Glass (1976) introduced the term "meta-analysis" to label the statistical analysis of results from individual studies "for purposes of integrating the findings" (p. 3). Meta-analysis is a quantitative approach to the problem of integrating a large and diverse body of literature within a specific field. It is the statistical averaging of the standardized results of many studies related to each other. Researchers carrying out a meta-analysis locate studies on an issue by clearly specified procedures. They characterize features of the studies and investigate outcomes in quantitative or semi-quantitative ways. Finally, meta-analysts use multivariate techniques to describe findings and relate characteristics of the studies to outcomes.

The meta-analytic methods are developed initially for handling the difficulties posed by the wealth and diversity of findings in the social sciences. When the number of studies of an issue is quite large, and findings are diverse, reviewers often see what they wish to see in the collected results. The use of quantitative methods and statistical tools enrich a reviewer's synthesis by the support of the data provided by the studies reviewed. By applying to a collection of results the same methods that researchers use in analyzing results from an individual study, the meta-analyst is able to draw reliable, reproducible, and general conclusions. Thus it is not just a technique, rather it is a perspective that uses many techniques of measurement and statistical analysis.

This study uses meta-analytic methodology to synthesize the research on the relationship between mathematics anxiety and mathematics achievement. In this chapter the methods and procedures are described for determining which studies are to be included in the analysis, locating studies, describing study features, quantifying study outcomes, and analyzing the data.

Criteria for Including Studies

To include a study in the current meta-analysis it is necessary to determine whether or not a study is concerned with the relationship between mathematics anxiety and mathematics achievement in elementary and/or secondary school students. In order to be selected for the final sample a study had to satisfy the criteria listed below. The study must:

1. Provide statistical data on mathematics anxiety and mathematics achievement from elementary or secondary school classroom settings. That is, the study had to provide statistics on a particular school grade level, age group or mathematics course. Studies carried out with vocational, technical, college or university subjects were not included in this study. For example, "Mathematics anxiety among talented students" by Lupkowski and Schumacker (1991) was eliminated because the subjects were college students.

2. Use validated instruments to measure mathematics anxiety. Studies without a mathematics anxiety measure or which used a test which had not been validated were not considered in this study. For example, "The content specificity of mathematics and English anxiety: the high school and beyond study" by Marsh (1988) was eliminated because mathematics anxiety was measured with four true or false questions for which validation was not assessed by the author.

3. Report the product-moment correlation coeffient, r, or sufficient information for its calculation. That is, the study had to provide data from which the correlation between mathematics anxiety and achievement in mathematics could be derived. Studies without the pertinent information to calculate the effect size were not selected for this study. For example, "Cognitive style and mathematics anxiety among high school students" by Hadfield and Maddux (1988) was eliminated because all they reported were MARS-A scores for low and high achievement students in mathematics making it impossible to calculate the correlations.

Additional criteria were applied to ensure that the set of studies used was as complete and representative of the mathematics anxiety-achievement relationship as possible. They were as follows:

a) When several papers reported the same comparison with the same sample, the single most complete report was retained for inclusion in this study.

b) When a comparison was made of the same sample in the same school for one or more years, the data from both years were retained, for example when the same subjects were tested two different years, year 1 and year 2 were coded.

c) When more than one measuring instrument was used in a study, the results of the instruments measuring mathematics anxiety and mathematics achievement were retained for the analysis.

d) When the female and male groups were clearly different in aptitude the data were not included. For example, when a comparison was made between females of a specific regular classroom with males with a special need or with learning disabilities.

e) When an achievement test was unfairly administered to the female or the male group the data were not included. For example, the male group was instructed about the test in advance while the female group was given the test without instruction.

Locating Studies

The first step in this meta-analysis was to collect studies that dealt with the relationship between mathematics anxiety and mathematics achievement. The primary sources for these studies were three library data bases. The data bases were: (a) Educational Resources Information Center (ERIC), a data base containing education-related reports, resumes and indexes, consisting of the two files Research in Education (RIE), and Current Index to Journals in Education (CIJE); (b) Psychological Abstracts (PSY), a data base containing a comprehensive compilation of nonevaluative summaries of literature in psychology and related disciplines; and (c) Dissertation Abstracts International (DAI), a data base containing abstracts of dissertations and theses. The secondary source was International ERIC consisting of the three files Australian Education Index (AEI), British Education Index (BEI), and Canadian Education Index (CEI).

The descriptors for mathematics anxiety used to search the data bases were mathematics anxiety, anxiety, students' anxiety, anxiety towards mathematics, and students' attitudes. The descriptors for achievement in mathematics were mathematics achievement, academic achievement, students' achievement, mathematics performance, academic performance, and students' performance. Following the method of Dusek and Joseph (1983) descriptors were entered as isolated words in order to perform a comparatively broad search.

RIE (1967-1994) provided 241 citations, CIJE (1972-1994), 218 and PSY (1972-1994) including DAI, 254. A manual search of the bibliographies from the primary sources yielded an additional 15 articles. In all, the bibliographic searches yielded a total of 728 titles. Most of the documents, however, failed in one way or another to meet the criteria established for the analysis. In cross-referencing, it was noted that several dissertations were later written as journal articles or technical reports. When this occured the journal article or report was used over the dissertation, because of the cost and amount of time required to retrieve the dissertation via interlibrary loan or from the authors. The abstract was printed for each citation. The abstracts were inspected and those that did not promise to yield relevant data, for example narrative, nonempirical articles, were excluded. Those that failed in one way or another to meet the established criteria for the analysis, for example studies of college or university students, were also excluded. On the basis of this selection process the number of citations was reduced to 82 in the following manner: First, 222 informative or narrative documents (62 in RIE, 97 in CIJE, 61 in PSY, and 2 in manual search) without any statistical data were eliminated because they did not meet any of the criteria. Second, 269 studies (72 in RIE, 55 in CIJE, 134 in PSY, and 8 in manual search) based on college students or other adults were eliminated due to sample. They did not meet criteria 1. Third, 78 (51 in RIE, 17 in CIJE, 9 in PSY, and 1 manually) documents dealing with teachers or curriculum guides were disqualified because they did not involve a classroom setting. They also did not meet criteria 1. Fourth, 69 studies (40 in RIE, 7 in CIJE, 20 in PSY, and 2 manually) that dealt mainly with other affective factors and lacked enough information about mathematics anxiety were also eliminated.

They did not meet criteria 2. Also 8 DAI documents (in PSY) could not be considered because they were not available for loan.

The remaining 82 documents were obtained and read in full. By applying the same criteria again 38 documents were eliminated because 16 (5 in RIE, 6 in CIJE, and 5 in PSY) dealt with attitudes, lacking enough data on mathematics anxiety, 17 (3 in RIE, and 14 in CIJE) were mainly concerned with computer or science anxieties, and 5 (3 in RIE, and 2 in PSY) because they were selected before from one of the other data bases.

A total of 44 studies were photocopied for a more rigorous inspection. Twenty-two documents were eliminated, thirteen because they lacked enough statistical data for correlation calculations and nine, obtained through interlibrary loan, were eliminated because they lacked necessary information mentioned in the abstract of the documents.

Table 3.1 summarizes the selection of the studies from the primary source.

With respect to International ERIC the same aproach was used; AEI provided 27 citations, BEI, 7 and CEI, 30. Once again the abstract was printed for each citation; the abstracts were inspected and citations that did not meet the established criteria were excluded. On the basis of this information about the documents contained in the abstracts 28 qualitative or narrative studies (16 in AEI, 3 in BEI, and 9 in CEI), 5 documents in AEI based on college students or other adults, 3 studies in BIE that dealt mainly with other affective factors without enough data on mathematics anxiety, and 18 curriculum guidelines in CEI were eliminated. From the 10 studies selected, one was found in a journal, and the rest were solicited by interlibrary loan. Of those one was based on university students, one did not contain enough data, and 5 were not available for loan.

Table 3.1

Summary of the study selection from the primary source

	RIE	CIJE	PSY	Manual	Total	Remain
Abstracts	241	218	254	15	728	
No Statistics	62	97	61	2	222	506
Wrong sample	72	55	134	8	269	237
No classroom setting	51	17	9	1	78	159
Other affective factors	40	7	20	2	69	90
Not available (DAI)			8		8	82
Read full text					82	
Mainly attitudes	5	6	5		16	66
Other anxieties	3	14			17	49
Repetition	3		2		5	44
Rigorous inspection					44	
Lack of Statistics	3	7	3		13	31
Misinformation		3	6		9	22
Total	239	206	248	13	706	
Remain	2	12	6	2	22	

Finally, 25 studies, 22 (3%) from the primary and 3 (5%) from the secondary sources, satisfied the criteria and were used for the sample. A bibliography of the 25 studies is given in Appendix A.

Describing Study Characteristics

The studies selected differed across a broad range of features such as school grade level, ability levels, mathematics anxiety instruments, and the quality of research designs. Their findings vary because of these characteristics. The meta-analytic procedures investigate relationships among the features of studies and their outcomes. For each study the following information was recorded:

- Author identification (for identification and reference)
- Form of publication (journal, ERIC, dissertation)
- Date of publication (1972 through 1994)
- Sample size (number of students)
- Gender (female, male)
- Grade level (one through 13)
- Ethnicity of subjects (predominant ethnic or cultural group, for example: Asian, Hispanic, black, white, or mixed/unreported)
- Instrument used for mathematics anxiety measurement (MAI, MAS, MARS, MARS-A, MARS-E, etc.)
- Instrument used for mathematics achievement measurement [Arithmetics Achievement Test (AAT), California Arithmetic Achievement Test (CAT), Comprehensive Test of Basic Skills (CTBS), etc.]

The independent variables are the studies' features related to the research questions, that is, gender, grade level, and ethnicity.

The dependent variable is the effect size estimated with a Pearson product-moment correlation coefficient (Rosenthal, 1991).

Quantifying Study Outcomes

The next task in this study was to describe quantitatively the outcomes of the studies in the sample. In this section the major outcome under consideration is the relationship between mathematics anxiety and mathematics achievement, and the extent to which this relationship varies across grade level, gender and ethnicity. The results of each study was transformed into a common effect size, the Pearson product-moment correlation coefficient.

The studies selected for the meta-analysis used diverse research designs. Some studies report results as differences between groups using statistics such as t and F, or by d (the standardized mean difference) which denotes an effect size in units of the standard normal distribution. Other studies report results as associations between variables using for example x^2 statistic. In order to conduct an empirical evaluation of this literature using meta-analytic procedures, it is necessary to convert all these various summary statistics into a simple common metric or effect size r in order to aggregate and synthesize them (Cohen, 1965, 1977; Friedman, 1968; Glass, McGaw, & Smith, 1981; Rosenthal, 1991). Guidelines for converting the most common test statistics to r are summarized in Table 3.2.

Table 3.2

Guidelines for converting various test statistics to r*

Statistic to be converted	Formula for transformation to r	Comments
t	$r = \sqrt{\frac{t^2}{t^2 + df}}$	
F	$r = \sqrt{\frac{F}{F + df(error)}}$	Use only for comparing two group means (i.e. df = 1 in the numerator)
x^2	$r = \sqrt{\frac{x^2}{n}}$	n = sample size. Use only for 2x2 frequency tables (df = 1)
d	$r = \frac{d}{\sqrt{d^2 + 4}}$	

*Source: Rosenthal (1991).

Data Analysis

The effect sizes concerning the relationship of mathematics anxiety and achievement in mathematics were partitioned into groups according to each research question. The homogeneity assumption was tested before any statistical interpretation was made. Each subgroup was analyzed separately, in expectation of using its average correlation to represent the subgroup. The use of the average was appropriate if the subgroup is consistent, which was determined by a Q-test of homogeneity (Hedges & Olkin, 1985). Whenever a subgroup of studies were homogeneous, the average value of the subgroup's correlations, weighted with respect to sample size, was declared the correlation or the effect for the subgroup research question. A 95% confidence interval was used to test the null hypothesis that the mean is not significantly different from zero. Whenever a subgroup was heterogenous, two conditions were used: the presence of outlier data, or interactions among independent and dependent variables. A search for the cause was then performed, to find and exclude the outlier data or to find and describe interactions, using procedures detailed by Hembree and Dessart (1986). Where a cause could not be found, the mean of the heterogeneous group was offered as a descriptor from which no statistical inferences were drawn.

The analysis of data is discussed in more detail in Chapter IV.

Summary

This chapter refers to methods and procedures of this research. They were explained by: determining the criteria for including studies, locating studies, describing study characteristics, quantifying study outcomes, and analyzing the data.

Chapter IV: Analysis of Data

Introduction

In this chapter, the results of the data analysis are presented and discussed. The primary purpose of this study was to analyze the available research on the relationship between mathematics anxiety and achievement in mathematics from elementary through secondary school by means of meta-analytic procedures. A secondary purpose of this study was to examine the extent to which the mathematics anxiety-mathematics achievement relationship varies across grade level, gender, and ethnicity.

The domain of review for this study was elementary through secondary school research on mathematics anxiety and mathematics achievement. Within this domain, elementary and secondary results were examined separately and jointly.

Four research questions guided this investigation:

Main Research Question. What is the magnitude of the relationship between mathematics anxiety and mathematics achievement for elementary and secondary school students, using the correlation coefficient r as a common metric?

Question 2. To what extent does the mathematics anxiety-mathematics achievement relationship vary across grade level?

Question 3. To what extent does the mathematics anxiety-mathematics achievement relationship vary across gender?

Question 4. To what extent does the mathematics anxiety-mathematics achievement relationship vary across ethnicity?

Procedures

The present study used meta-analysis to synthesize research on the relationship between mathematics anxiety and mathematics achievement in elementary and secondary school students. The first step was to collect studies that dealt with this relationship. On the basis of the selection process described in Chapter III the number of 728 citations was reduced to a final sample of 25 studies that were analyzed in this research.

Sample

The sample of studies consisted of refereed journal articles (18), theses or dissertations (5), and unpublished papers (2). Two of the studies were conducted between 1970 and 1979, 12 between 1980 and 1989, and 11 between 1990 and 1994. The majority of these studies were conducted in the United States (18). The remainder consisted of two in Australia, two in Israel, one in Lebanon, one in Thailand and the United States, and one in New Zealand.

Forty seven effect sizes were analyzed from the 25 studies, listed in Appendix A. The smallest sample size of these 47 correlations was 28 and the largest was 4091. A total of 22 189 students from a diversity of socio-economic backgrounds were involved in the study.

Instruments

The instruments used by the studies to measure mathematics anxiety were the Mathematics Anxiety Test (MA) (2), the MAI (2), the Mathematics Anxiety Questionnaire (MAQ) (2), the MARS (4), the MARS-A (6), the MARS-E (2), the MAS (5), the MASC (2), and the test used by the Second International Mathematics Study (SIMS) (1). Each of these instruments was reported to be validated before being implemented in their studies.

The instruments used by the studies to measure mathematics achievement were the Arithmetics Achievement Test (AAT) (1), the California Arithmetic Achievement Test (CAT) (1), the Comprehensive Test of Basic Skills (CTBS) (3), the Iowa Test of Basic Skills (ITBS) (1), the Mathematics Achievement Test (MAT) (1), the Missouri Mathematics Placement Test (MMPT) (1), the mathematics teacher grades (MTG) (10), the Progressive Achievement Test (PAT) (1), the researcher made test (RMT) (1), the Scholastic Aptitude Test for Mathematics (SAT-M) (1), the Stanford Achievement Test (SAT) (3), and the test used by the SIMS (1). Each of these instruments was assessed to be valid before being implemented in their studies.

The File Drawer Problem

The file drawer problem refers to the selective bias which occurs when only published studies are available for analysis while many unpublished studies are buried in file drawers. Many of these file-drawer studies include non-significant results. Rosenthal (1979, 1991) cites this when some researchers do not report findings which are not statistically significant, such as $p>0.05$.

According to Rosenthal (1979, 1991), a meta-analysis study is considered to be resistant to the file drawer problem of unreported null effects if the tolerance level, fail-safe $x = 19s-n$, is larger than the requisite number, $5k+10$, where $\underline{s}$ is the number of significant effect sizes, $\underline{n}$ is the number of nonsignificant effect sizes, and $\underline{k}$ is the number of reported effect sizes.

In this meta-analisis one effect size was not reported whether it was significant or not, two were calculated for which it was impossible to decide their significance. By treating all undecidable results as nonsignificant in this study one gets $\underline{k}$ = 47, $\underline{s}$ = 44, and $\underline{n}$ =3, so 5k+10 = 245 and the fail-safe $\underline{x}$ equal to 833, far larger than the requisite number. Therefore, the file drawer problem was not a concern in this study.

Analysis

To answer the research questions the total collection of data was partitioned into groups, relating to each of the questions. Each group was analyzed separately, with the expectation that its average correlation could be used to represent the group, thus becoming the correlation or the effect size that answered the question. For an average correlation to represent its subgroup inferentially, each item of data must estimate the underlying population value. Where such a circumstance exists, the subgroup of data is homogeneous, all its variance resulting from sampling error, in such a case the average correlation properly estimates the population average, and confidence intervals for the average correlation are also valid. However, if its variance exceeds the amount expected by chance, the subgroup is heterogeneous, and its average correlation cannot be said to estimate the population average. Outlier data points in the subgroup may cause the excessive variability. Another potential cause is a relationship between the dependent variable and an independent variable, that is, the data may vary as a function of a study characteristic, such as school grade level. If so, the population parameters are multiple rather than single, and the data in the subgroup are estimating two or more population values.

As mentioned in Chapter III each analysis began with the Q-test statistic for homogeneity of the correlations in a given group. The test provided a chi-square statistic for k-1 degrees of freedom and a 0.05 significance level, where k is the number of correlations in the group. $Q = \sum_{j=1}^{k} (N_j - 3)(Z_{rj} - \overline{Z}_r)^2$, where Z_{rj} is the Fisher's Z_r (corresponding to any r), and $\overline{Z}_r$ is the weighted average Z_r, that is, $\overline{Z}_r = \sum_{j=1}^{k}(N_j - 3)Z_{rj} \Big/ \sum_{j=1}^{k}(N_j - 3)$. If the test statistic was not significant, its subgroup of data was homogeneous. If the subgroup data was homogeneous the average value, weighted with respect to sample sizes, and its 95% confidence interval were computed. Each average was declared the correlation or effect that answered its research question. The confidence interval tested the null hypothesis that the average correlation was not significantly different from zero.

However, if Q was significant, the subgroup was heterogeneous due to the influence of outliers or relationships between the dependent and independent variables. When heterogeneity was disclosed for any group, a search for the cause was initiated, using Hembree and Dessart's (1986) procedures: (a) deleting outliers (if any) and (b) subgrouping the data by categories of the independent variables and testing these subgroups for homogeneity. The revelation of homogeneous subgroups within the heterogeneous data group described the relations and interactions among the independent and dependent variables.

To identify an outlier, that potentially had contributed to the excessive variance of the heterogeneous group, an interval is created with the average correlation of the group as the mid point. The outliers are the correlations that fell beyond the left or right-hand bracket when the interval is reduced. Each time an outlier is deleted a new Q-test is done until a homogeneous group is found.

Results and Discussion

Overview of the data. The result of each study was transformed into a common effect size, the Pearson product-moment correlation coefficient. Summary statistics for these correlations are given in Table 4.1.

Table 4.1
Correlations between mathematics anxiety and mathematics achievement

Study*	Instruments	Sample	Grades	Correlation	Comments
1	MARS MTG	418	9, 10, 11, 12	-0.42	Israeli students (Arabians)
2	MAI CTBS	714	7	-0.28 -0.27 -0.24 -0.30	Mathematics concepts Mathematics applications Mathematics computation Mathematics total
3	MARS-A ITBS	584	4, 5, 6	+0.49 +0.19	Adapted MARS-A
4	MASC MTG	50 56 115	5 6 8	-0.37 -0.24 -0.47	
5	MAS MMPT	290	12	-0.47	white students
6	MARS-A CAT	177	10	-0.85	CAT post test
7	MA SAT-M	164	7, 8, 9	-0.17	
8	SIMS	4091 3613	8 8	-0.24 -0.14	USA Thailand

9	MARS-A CTBS	95	9, 10, 11, 12 9, 10, 11, 12 9, 10, 11, 12 9, 10, 11, 12	-0.13 -0.15 -0.10 -0.12	Mathematics concepts Mathematics applications Mathematics computation Mathematics total
10	MARS MAS MTG	496	7, 8, 9, 10, 11, 12	-0.35	Australian students
11	MARS-A CTBS	358	8, 9, 10	-0.23	Native Indian students
12	MAS MTG	255	6	-0.27	
13	MAQ RMT	250	7, 8, 9	-0.17	Year 1: -0.13 Year 2: -0.21 white students
14	MA AAT	149	6	-0.44	Israeli students
15	MAS SAT	407	9, 10, 11, 12	-0.28	white students
16	MARS-A MTG	133	9, 10, 11, 12	-0.60 -0.48	Male Female (Lebanese students)
17	MAI MAT	4612	8 11	-0.47 -0.17	
18	MASC PAT	132 114	6 6	-0.28 -0.30	Male Female New Zealand students
19	MARS-A MTG	28 1009	7,8,9,10,11, 12	-0.59 -0.20	School A School B
20	MARS-E SAT	1119	4, 5, 6	-0.29 -0.26 -0.26 -0.31	Mathematics concepts Mathematics applications Mathematics computation Mathematics total
21	MARS-E SAT	105	4, 5, 6	-0.22 -0.23 -0.23 -0.28	Mathematics concepts Mathematics applications Mathematics computation Mathematics total (Hispanic students)
22	MAS MTG	1516	6, 7, 8, 9, 10, 11, 12	-0.47	
23	MARS MTG	59	8	-0.31	

24	MAQ MTG	564	6, 7, 8, 9, 10, 11, 12	-0.24	Year 1: -0.22 Year 2: -0.26 white students
25	MARS MTG	516	10	-0.51 -0.24 -0.41	Male Female Total Australian students

Note. * The studies identification number are given in Appendix B.

To examine the spread and distribution of the data, Tukey (1977) suggested the use of a stem-and-leaf plot. Figure 4.1 displays the 47 correlations from the 25 studies which have to be tested for homogeneity by the Hedges and Olkin (1985) Q-statistic criteria. The first decimal place of the correlation is represented on the stem to the left of the vertical line; the second place is represented as a leaf to the right of the vertical line.

5	
4	9
3	
2	
1	9
0	
-0	
-1	02345777
-2	02333444446677788889
-3	001157
-4	12477778
-5	19
-6	0
-7	
-8	5
-9	

Figure 4.1. Stem-and-leaf display of the 47 effect sizes.

Study number 3 (Bush, 1991), with grade 4, 5, and 6 students, is the only one that claims a positive relationship between mathematics anxiety and mathematics achievement (0.49 with the ITBS concept residual gain score and 0.19 with the ITBS problem solving residual gain) in contrast to the other studies. Bush himself recognizes that "it represented a contradiction of previous research on the relationship between mathematics anxiety and achievement" (p. 42), but he does not give an explanation for this contradiction. It appears that in Bush study the range of severity of the mathematics anxiety measurement was limited because the students have perhaps been extensibly exposed to mathematics. If this was the case and because all the other studies report negative correlation between mathematics anxiety and mathematics achievement, the positive correlation can therefore be attributed to sampling error.

The highest negative correlation was found in study 6 by Donnelly (1986). His study which involve grade 10 students concluded that the correlation between the MARS-A and the CAT is -0.85. On the other hand Wither (1988) found with grade 10 students in study 25 a lower correlation of -0.41 between MARS and mathematics total. This can imply that MARS-A is more sensitive and therefore gave higher scores than MARS, or that MARS-A may be was wrongly administered in Donnelly's study.

Main Research Question. What is the magnitude of the relationship between mathematics anxiety and mathematics achievement for elementary and secondary school students, using the correlation coefficient r as a common metric?

Following the procedure described by Hedges and Olkin (1985) each correlation outcome of the individual studies was treated as a unit of analysis. For studies that contained more than one effect size, weighted averages were used to combine correlations in that individual study. To guard against skewness of the sampling distribution, each r was transformed into its associated z statistics using Fisher's r to Z_r transformation (Ferguson, 1981, p. 194). These Z_r's were averaged using the formula for $\bar{Z}_r$ given before, in the analysis section, and then transformed back to r. The r to Z_r or Z_r to r table was used to look up the r associated with the average Z_r. The $\bar{r}$ (average r) and not the $\bar{Z}_r$ (Fisher r average) was used and reported as the correlation indicator (Rosenthal, 1991, p. 87; Hedges & Olkin, 1985, p. 231).

The question was addressed by 25 correlations ranging from -0.85 to 0.35 that are shown in Figure 4.2. The group was heterogeneous, Q(24, k=25) = 138.74, p<.05, where 24 is the number of degrees of freedom.

5	
4	
3	5
2	
1	
0	
-0	
-1	3779
-2	34478889
-3	1259
-4	012477
-5	4
-6	
-7	
-8	5
-9	

Figure 4.2. Stem-and-leaf display of the 25 correlations used with the Main Research Question.

Following the procedures described earlier three homogeneous groups resulted after removing outliers and applying the Q test. The first homogeneous group was the group including the studies 7, 8, 9, 11, 12, 13, 21, and 24, with the majority of the subjects from lower grades, with correlations from -0.27 to -0.13 , Q(7, k=8) = 7.15, p>.05. Its average correlation was -0.20 with 95% percent confidence interval ranging from -0.22 to -0.18. Because zero is not contained in this interval, the average was statistically different from zero. This group appears to be influenced by study number 8 that has the largest total sample size (7704 students) with average correlation of -0.19.

According to Cohen (1977) r = 0.10 is considered small, r = 0.30 medium, and r = 0.50 large; this means that the first group has a relative small negative average. The instruments for mathematics anxiety most used in this group were MARS-A and MAQ (in two studies each), and for mathematics achievement were the MTG and the CTBS (in two studies each).

The relationship can be illustrated by the Binomial Effect Size Display (BESD) (Rosenthal, 1991) as well, if both variables are simplified into dichotomies. The BESD is the difference in success probabilities between two groups. Practically speaking with this transformation table one can interpret r in terms of success or improvement rates attributed to two groups. According to this illustration method, the first group with $\bar{r}$ = -0.20, 60% of the low mathematics-anxious students would be above the mathematics achievement average compared to only 40% of the high mathematics-anxious students.

The second homogeneous group to be found was the group including the studies 2, 4, 10, 15, 17, 18, 20, and 23 with correlations from -0.39 to -0.28 , Q(7, k=8) = 7.05, p>.05. Its average correlation was -0.32 with 95% percent confidence interval ranging from -0.34 to -0.30. Because zero is not contained in this interval, the average was statistically different from zero. This group appears to be influenced by study number 17 that has the largest total sample size (4612 students) with average correlation of -0.32. This group has a medium negative average correlation and includes studies with elementary and secondary grades. The instruments more frequently used here were the MAI and MARS (in two studies each) for mathematics anxiety, and the MTG (in 3 studies), and the SAT (in 2 studies) for mathematics achievement. According to the BESD for this group, 66% of the low mathematics-anxious students would be above the mathematics achievement average compared to only 34% of the high mathematics-anxious students.

The third homogeneous group was the group including the studies numbered 1, 5, 14, 16, 19, 22, and 25 with correlations from -0.54 to -0.40, $Q(6, k=7) = 8.45$, $p>.05$. Its average correlation was -0.43 with 95% percent confidence interval ranging from -0.46 to -0.41. Because zero is not contained in this interval, the average was statistically different from zero. This group also appears to be influenced by the studies with the largest sample size, numbered 19 and 22 with 1037 and 1516 students and average correlation of -0.40 and -0.47 respectively. This group has a relative large negative average correlation with the majority of the subjects from secondary grades. The instruments more frequently used were MAS and MARS (in two studies each) for mathematics anxiety, and the MTG (in 4 studies) for mathematics achievement. According to the BESD for this group, 72% of the low mathematics-anxious students would be above the mathematics achievement average compared to only 28% of the high mathematics-anxious students.

With respect to the arousal theory there is not enough evidence to find out whether each of the three average correlations, -0.19, -0.32, and

-0.43 respectively, are in, above, or below the range of optimal level of mathematics anxiety. The empirical information still seems to be too small to decide upon the question whether mathematics anxiety shows an arousal curve or correlates even positively with some mathematics achievement topics.

The relationship is clearly negative, which means that high mathematics anxiety is related to lower mathematics achievement. This would seem to indicate that students who are anxious about mathematics are likely to achieve mathematics scores at a lower level than their counterparts who do not exhibit the same high levels of mathematics anxiety.

Question 2. To what extent does the mathematics anxiety-mathematics achievement relationship vary across grade level?

The mathematics anxiety-mathematics achievement correlation across grade level is illustrated in Table 4.2. This group (grades 4, 5, 6, 7, 8, 10, 11, and 12) contained eight average correlations from -0.47 to -0.17. The group was heterogeneous, $Q(7, k=8) = 47.27$, $p<.05$, where 7 is the number of degree of freedom. This group was divided into two subgroups: The group from grades 4 to 8 was homogeneous, $Q(4, k=5) = 1.02$, $p>.05$. Its average correlation was -0.26 with 95% percent confidence interval ranging from -0.27 to -0.24. Because zero is not contained in this interval, the average was statistically significantly different from zero. This group appears to be influenced by the grade 8 subgroup which has a sample of 7878 students and average correlation of -0.24. On the other hand, the group from grades 10 to 12 was heterogeneous, $Q(2, k=3) = 37.28$, $p<.05$.

Table 4.2

Statistics of the mathematics anxiety-mathematics achievement relationship across grade

Grade	Persons	Number of r	Average r	95%CI® of Average
1•				
2•				
3•				
4	1182	4	-0.26*	(-0.31, -0.21)
5	1230	5	-0.29*	(-0.34, -0.24)
6	2200	9	-0.29*	(-0.33, -0.25)
7	714	1	-0.27*	(-0.33, -0.19)
8	7878	4(2)*	-0.24*	(-0.27, -0.21)
9•				
10	516	2(1)*	-0.41*	(-0.47, -0.35)
11	2542	1	-0.17*	(-0.21, -0.13)
12	290	1	-0.47*	(-0.51, -0.42)
E®	1330	3(1)*	-0.27*	(-0.31, -0.23)
S1®	2084	4	-0.40*	(-0.43, -0.37)
S2®	1110	4	-0.23*	(-0.28, -0.17)

Note. * p<0.05; Number of outliers excluded are in parenthesis.

® CI = Confidence Interval; E=Elementary School (grades 4 to 6); S1, S2 = Secondary School (grades 7 to 12). Two homogeneous groups.

• No studies at this grade level.

Figure 4.3 illustrates the average correlations across grade level. The graph shows that the relationship is not the same over grade levels. For grades 4 to 8 the relationship remains rather stable, but there is a dramatic swing in grades 10 to 12. Note that there were no studies found dealing with the ninth grade alone.

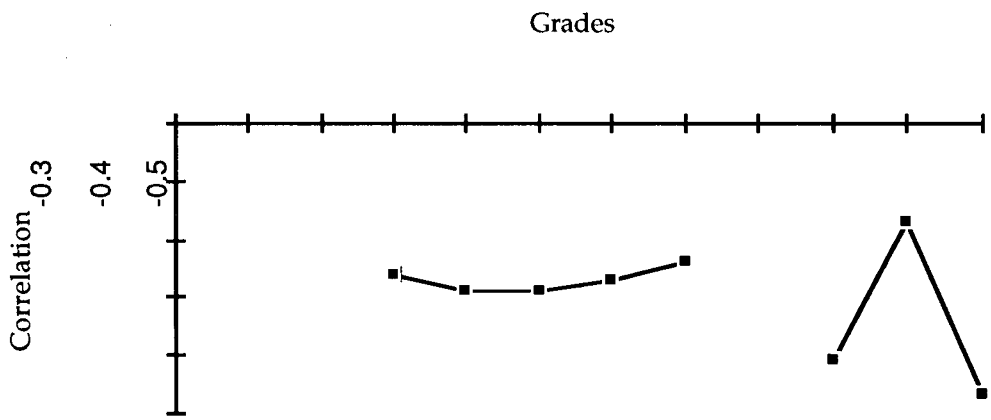

Figure 4.3. Mathematics anxiety-mathematics achievement correlations across grade.

Table 4.2 also indicates the combined correlations for studies concerning more than one elementary grade (E) and the combined correlations for studies involving more than one secondary grade (S). The average correlation, after eliminating the outliers 0.49 and 0.19, for E is -0.27 with Q(2, k=3) = 0.39, p>.05 and 95% confidence interval ranging from -0.31 to -0.23. In the group of S were found two homogeneous subgroups. The first group for S (S1) with correlations from -0.54 to -0.35; its average correlation was -0.40, Q(3, k=4) = 6.20, p>.05 and 95 % confidence interval from -0.43 to -0.37. The second group for S (S2) with correlations from -0.28 to -0.13; its average correlation was -0.23, Q(3, k=4) = 3.10, p>.05 and 95 % confidence interval from -0.26 to -0.17. Since the confidence intervals of E and S2 do overlap, they are not considered statistically different, but E and S1 are statistically different across the groups because their confidence intervals do not overlap. That is, an increase may be seen in the inverse relationship between mathematics anxiety and mathematics achievement from the elementary level, with an average correlation of -0.27, to the secondary level with average correlation of -0.40.

These findings are in agreement with what Green (1991), in study number 10 in this meta-analysis, found with Australian students from grade 7 to 12. He concluded that "students with anxiety about mathematics were found to have poorer attitudes toward mathematics and vice versa. The students with poor attitudes were found to be from the more senior years and students with positive attitudes were more likely to come from the lower secondary years" (p. 105).

Question 3. To what extent does the mathematics anxiety-mathematics achievement relationship vary across gender ?

Table 4.3

Statistics of the mathematics anxiety-mathematics achievement relationship by gender

Gender	Persons	Number of r	Average r	95%CI® of Average
Mixed 1	14495	8	-0.20*	(-0.22, -0.18)
Mixed 2	7761	8	-0.32*	(-0.34, -0.30)
Mixed 3	4802	7	-0.43*	(-0.46, -0.41)
Male	674	3(2)*	-0.25*	(-0.32, -0.18)
Female	419	3(2)*	-0.26*	(-0.34, -0.16)

Note. * $p<0.05$; Number of outliers in parenthesis.

® CI = Confidence Interval.

Table 4.3 shows the average correlation across gender. Only those studies that report correlations, or data for its calculation, separately for both males and females are used here. The average correlation for males is -0.26 and -0.25 for females. The mathematics anxiety-mathematics achievement relationship appeared fairly consistent across gender groups; there were no statistically significant gender differences in the relationship as evidenced by their overlapping confidence intervals. The response to Question 3 is that the mathematics anxiety-mathematics achievement relationship does not vary across gender.

This finding contradicts Hembree's (1990) meta-analysis, which found that, from studies until 1987, the inverse relationship was stronger for males than females, from grade 6 to 12, with average correlation of -0.36 and -0.30 respectively. However, this difference was not statistically significant because their confidence intervals overlapped. The fact that this meta-analysis used studies until 1992 with a sample from grade 4 to 12, from which only 3 were also used in Hembree's study, may explain the contradiction in results.

<u>Question 4.</u> To what extent does the mathematics anxiety-mathematics achievement relationship vary across ethnicity ?

The average correlations for ethnic backgrounds are shown in Table 4.4. In this meta-analysis Australian and Israeli students were considered different ethnic groups from "whites" that referred to predominantly white students in the USA. The ethnicity group contained six average correlations from -0.42 to -0.14 representing "mixed (USA)", "Asians", "Australians", "Israelis", "Hispanics", and "whites". The group was heterogeneous, $Q(5, k=6) = 19.56$, $p<.05$.

Table 4.4

Statistics of the mathematics anxiety-mathematics achievement relationship by ethnicity

Ethnicity	Persons	Number of r	Average r	95%CI® of Average
Mixed (USA)	6923	6(2)*	-0.32*	(-0.34, -0.29)
Asians	3631	2	-0.14*	(-0.17, -0.11)
Australians	1012	3	-0.36*	(-0.41, -0.30)
Israelis	567	2	-0.42*	(-0.49, -0.35)
Hispanics	448	6	-0.25*	(-0.33, -0.16)
Whites	1491	4	-0.29	(-0.33,-0.24)

Note. * $p<0.05$; Number of outliers in parenthesis.
® CI = Confidence Interval.

From Table 4.4, it may be seen that the weakest correlation was for Asian students which implies that mathematics anxiety has lower correlation with their mathematics achievement tests than it does for the other ethnic groups involved in the studies. On the other hand, the inverse relationship looks the strongest for the Israeli students. Australian, Hispanic, mixed, and white students appeared to have no statistically significant differences across the groups as evidenced by their overlapping confidence intervals.

Table 4.4 further indicates that the confidence interval of the Australian students overlaps with the confidence interval of the Israeli students, and the confidence interval of the Hispanics students overlaps with the confidence interval of the Asian students. Note, there were no studies found dealing with correlations for black students.

Overall, it appears that there are not significant ethnic differences in the relationship between mathematics anxiety and mathematics achievement.

Summary

The results of this study found significant negative correlation between mathematics anxiety and mathematics achievement. This finding confirms earlier research indicating that there is an inverse relationship between mathematics anxiety and mathematics achievement (Betz, 1978; Llabre & Saurez, 1985; Hembree, 1990). This would seem to indicate that students who report higher levels of mathematics anxiety tend to have lower scores on the mathematics achievement tests.

The results of the study seem to indicate that the negative correlation between mathematics anxiety and mathematics achievement is not the same across grade level. However, by combining the average correlations for studies concerning more than one grade, an increase may be seen from the elementary to the secondary grades. It should also be noted that this meta-analysis found no studies for grades one, two, three, or nine.

The results of the study show no statistical difference in the mathematics anxiety-mathematics achievement relationship across gender.

With respect to ethnicity, the results of the study indicate that the weakest and strongest negative average correlations appeared to be for the Asian and Israeli students respectively. The average correlation of

Australian, Hispanic, mixed, and white students appeared to be higher than that of the Asian students, but lower than the Israeli students. It should also be noted that this meta-analysis found no study with correlations for black students.

Chapter V: Summary, Conclusions, and Recommendations

Introduction

The primary purpose of this study was to use meta-analysis to analyze the research on the relationship between mathematics anxiety and mathematics achievement. The study was intended to make two distinct contributions to the existing body of literature relating mathematics anxiety and mathematics achievement. First, it was intended to review the findings of studies within the different data bases, and to help explore the relationship between mathematics anxiety and mathematics achievement through the elementary and secondary school levels. Second, it was intended to provide a basis for recommendations concerning the variation of this relationship across the variables of grade level, gender, and ethnicity.

This chapter summarizes the findings of the study, and presents conclusions and recommendations based on the study's findings.

Summary

There have been literature reviews in the area of mathematics attitudes without the use of statistical tests, and without emphasis on mathematics anxiety. Most studies in mathematics anxiety have been with college students and adults. The trend of the findings in these studies suggests that there is a negative relationship between mathematics anxiety and mathematics achievement at the college and university level.

The unit of analysis came from the 25 studies of elementary and/or secondary students on mathematics anxiety related to mathematics achievement. Forty-seven effect sizes were analyzed, representing 22 189 students. The major outcomes were that there is a significant negative correlation between mathematics anxiety and mathematics achievement in elementary and secondary students; the negative relationship seems to increase from the elementary to the secondary grades. No significant statistical differences were found in the mathematics anxiety-mathematics achievement relationship across gender. The strength of the negative correlation varies across ethnic group.

Conclusions

The following conclusions concerning mathematics anxiety and its relationship to mathematics achievement were drawn from the analysis of the data presented in Chapter IV:

1. The results of this meta-analysis seem to indicate that there is a negative correlation between mathematics anxiety and mathematics achievement. This means that lower mathematics anxiety may lead to a higher mathematics achievement. Mathematics anxiety could, therefore, have a negative effect on children's scores on mathematics achievement tests. This could seem to indicate that reduction in mathematics anxiety would enhance mathematics achievement.

2. The findings from the meta-analysis also indicated a significant negative correlations between mathematics anxiety and mathematics achievement across grade level, which seem to get stronger from the elementary to the secondary level.

3. The results of the studies showed that there were no statistically significant differences in the mathematics anxiety-mathematics achievement relationship across gender.

4. The results of the studies report that the mathematics anxiety-mathematics achievement relationship varies across ethnicity.

Suggestions for Further Research

The following suggestions are made concerning further research, the use of results, and inclusion of certain statistics in studies on mathematics anxiety and its relationship to mathematics achievement.

1. Because of the significance of the negative correlation between mathematics anxiety and mathematics achievement, further research is needed to identify the underlying causes and potential remedies for mathematics anxiety at the elementary and secondary school levels.

2. Because the majority of the studies do not report enough information concerning their sample, it is recommended that future studies should report about the social and economic background of the subjects.

3. Because the majority of the studies were conducted at the secondary level, and there were no studies found for this meta-analysis containing samples from grade one, two and three, it is recommended that more studies should be carried out using samples of elementary students, especially using grades one, two, and three as a sample.

4. Because of the extreme results, which were out of line with other similar instruments, it is suggested the MARS-A be revised before being used for the measurement of mathematics anxiety. Because MARS was developed using college and adult students, it is not recommended its use with elementary or secondary students. It is also recommended that the MARS-A, MARS-E, and MASC be refined for use with students from Kindergarten to grade 3.

5. Because of the lack of studies containing samples from grade nine alone, it is recommended that more studies should be done on the mathematics anxiety-mathematics achievement relationship using grade 9 students.

6. Because of the lack of studies containing samples from black students alone, it is suggested that more studies should be done on the mathematics anxiety-mathematics achievement relationship using black students.

7. It is recommended that a more complete set of summary statistics be reported in research studies on the relationship between mathematics anxiety and mathematics achievement. Of a potential pool of 82 studies, only 25 contained enough information to calculate the correlation.

8. Only two of the twenty-five studies provided information from longitudinal studies. Based upon this small number, it is recommended that more longitudinal studies should be done on the relationship between mathematics anxiety and mathematics achievement.

9. Because of the lack of availability of many of the studies on the relationship between mathematics anxiety and mathematics achievement, a repository for summary data for all theses, dissertations, published and unpublished studies should be established. This repository would be useful to later researchers.

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Appendix B: Studies Identified by Numbers

Studies Identification Number

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11. Hadfield, O. D., Martin, J. V., & Wooden S. (1992).
12. Lee, B. Y. (1992).
13. Meece, J. L., Wigfield A., & Eccles J. S. (1990).
14. Mevarech, J. S., Silber, O. & Fine, D. (1991).
15. Reavis, P. S. (1989).
16. Saigh, P. A., & Khouri A. (1983).
17. Sandman, R. S. (1979).
18. Sepie, A. C., & Keeling, B. (1979).
19. Suinn, R. M., & Edwards, R. W. (1982).
20. Suinn, R. M., Taylor S. , & Edwards, R. W. (1988a).
21. Suinn, R. M., Taylor S. , & Edwards, R. W. (1988b).
22. Thordike-Christ, T. (1991).
23. Wahl, M. W. (1987).
24. Wigfield A., & Meece, J. L. (1988).
25. Wither, D. (1988).