Math Anxiety, Math Self-Concept, and Performance in Math

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Abstract

This study analyzed the relationship among math anxiety, math self-concept and performance in math. The study examined descriptive, and correlational relationships among these variables, and explored gender differences in the relationship, math anxiety, and math self-concept. Three hundred and twenty grade 10 advanced students (174 female, 145 male) from two school boards in Northwestern Ontario served as subjects. Measures of correlation revealed that higher levels of math anxiety were accompanied by lower performance in math, and lower math self -concept. Higher math self-concept was linked to higher performance. These relationships held for males and females separately. Math self-concept was significantly more closely linked to performance than was math anxiety, and this was so for each gender separately. The correlations for math anxiety/performance, and for math self-concept /performance were similar in magnitude for both genders, indicating that math anxiety and math self-concept functioned similarly for both males and females with respect to performance. T-tests revealed that females had significantly higher math anxiety, and lower math self-concept than males.

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CHAPTER I

INTRODUCTION

For the past three decades researchers have been investigating the relationship between performance in mathematics and affective variables related to mathematics. In this study, two of these were examined: Math anxiety and math self-concept.

Math anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and with the solving of mathematical problems in a wide variety of situations, both in academic and ordinary daily activities (Richardson & Suinn, 1972, p. 551). It is "a feeling of apprehension, out of proportion to any actual threat, which is experienced in reaction to a situation involving the use of mathematics" (Boodt, 1979, p. 28).

Math self-concept has received considerable attention because of its relationship to math anxiety and to performance in math. Math self-concept refers to a person's perceived ability to learn mathematics. Reyes (1984) stated that math self-concept, "has to do with how sure a person is of being able to learn new topics in mathematics, perform well in mathematics class, and do well on mathematics tests" (p. 560).

Purpose of the Study

The purpose of this study was to investigate the nature of the relationship among math anxiety, math self-concept, and performance in mathematics. The study examined descriptive, and correlational relationships among these variables, and explored gender differences in the relationships, math anxiety, and math self-concept. This study focused on three relationships: math anxiety/performance, math self-concept/performance, and math anxiety/math self-concept. The following research questions were examined:

Research Questions

1. a) Do higher levels of math anxiety accompany lower levels of performance among grade 10 advanced students in Northwestern Ontario? b) Does this relationship exist for males and females?
2. a) Are higher levels of math self-concept linked to higher levels of performance among grade 10 advanced students in Northwestern Ontario? b) Does this relationship exist for males and females?
3. a) Are higher levels of math anxiety accompanied by lower levels of math self-concept among grade 10 advanced students in Northwestern Ontario? b) Does this relationship exist for males and females?
4. Is there a difference in the strength of the math anxiety/performance relationship, and the math self-concept/performance relationship?
5. Is there a gender difference in the strength of the math anxiety/performance relationship, or the math self-concept/performance relationship?
6. Is there is a gender gap in math anxiety, or math self-concept?

Background

Research has typically found that among both students in university and preuniversity higher levels of math anxiety are accompanied by lower levels of performance in math (Betz, 1978; Resnick, Viehe, & Segal, 1982; Adams & Holcomb, 1986; Tocci & Engelhard, 1991; Ma, 1999), and that higher levels of math self-concept are linked to lower levels of math anxiety (Gourgey, 1982; Hackett & Betz, 1989; Hembree, 1990; Thorndike-Christ, 1991). Furthermore, students who have higher math self-concept outperform students with lower math self-concept (Fennema & Sherman, 1977, 1978; Sherman, 1979; Rounds & Hendel, 1980; Tartre & Fennema, 1995; Casey, Nuttall, & Pezaris, 1997).

There does not appear to be a significant difference in the relative strength of the math anxiety/performance, or the math self-concept/performance relationships among females and males in university or preuniversity (e.g., Sherman, 1979). Hence, math self-concept, and math anxiety appear to function in a similar fashion for both genders with respect to performance.

Research has typically found that math self-concept is more closely linked to performance than is math anxiety (e.g., Thorndike-Christ, 1991; Pajares & Miller, 1994). The characteristic has been found in university and preuniversity students, but has not been established among males and females separately.

Gender differences in math self-concept, and in math anxiety, have been examined with conflicting results. Various researchers have found females to have higher math anxiety than males (e.g., Llabre & Suarez, 1985; Wigfeild & Meece, 1988; Hembree, 1990), while others have found no gender difference (Ohlson & Mein, 1977; Resnick, Viehe, & Segal, 1982).

In studies involving university students, males and females are typically found to have similar math self-concept (e.g., Pajares & Miller, 1994). However, among preuniversity students, research is not consistent. Math self-concept is often found to be lower among females than males (Fennema & Sherman, 1978; Thorndike-Christ, 1991), but several studies have found that the gender difference is not statistically significant (Hackett & Betz, 1989; Tartre & Fennema, 1995). The literature presents a hazy picture of gender differences in math anxiety and math self-concept.

Rationale and Significance of the Study

In an increasingly technological and global economy, a strong background in mathematics is of critical advantage in gaining personally rewarding careers at technical, professional, and managerial levels. The Toronto Board of Education (1983) called math a key to the future, and argued that "young people without that key are constrained in their choices of post-secondary courses and programs, and consequently in their career options available to them" (p. 11).

Clearly, performing well in math will greatly increase the future career opportunities for students. Mathematics is a cognitive endeavor; an understanding of the concepts, and thought processes within the discipline is vital to performing well on mathematical tasks, and assessments. However, math anxiety and math self-concept have been found to be salient variables related to performance in math. It is important to better understand the relationship among math anxiety, math self-concept, and performance so that students' performance can best be facilitated.

The impact of high math anxiety, low math self-concept and their associated low performance may be greatest among Ontario students in grade 10. It is well established that performance, and math anxiety are strong predictors of the enrollment intentions of a student: The better the mark a student receives in math, and the lower his/her math anxiety, the more ambitious his/her plans are in pursuing advanced math or math related fields like engineering (Betz, 1978; Hendel, 1980; Wigfeild & Meece, 1988; Meece, Wigfeild, & Eccles, 1990). Grade 10 is the last year in which students in Ontario are required to take math. After Grade 10, students must either decide to pursue more advanced math or drop math and seriously limit their futures. Grade 10 is a critical year in which to examine the relationship between math anxiety and performance, including gender differences in this relationship.

Math anxiety is perhaps the most studied attitudinal variable related to math education. Studying math anxiety is important due to its potential indirect effects. In addition to math avoidance, math anxious students may be more likely to have negative attitudes toward math-related activities such as those encountered with computers (Gressard & Loyd, 1987), or statistics (Adams & Holcomb, 1986), and if they become elementary school teachers, may spend less time teaching math than their less anxious colleagues (Trice & Ogden, 1987).

It is important to probe further into the question of the existence of a gender gap in math anxiety, and math self-concept. Such knowledge will provide direction in prevention and treatment programs of math anxiety, and low math self-concept, and act as a catalyst in the alleviation of a gender gap in these areas, if the purported gap exists.

The majority of research on math anxiety, and its relationship to math self-concept, and performance, has been conducted in the United States. Few have been done in Canada, and few studies have focused on university-bound students as the current study does. This study sought to expand and replicate previous research in Northwestern Ontario among advanced students.

Definitions

The following definitions were adopted in this study.

Mathematics anxiety—feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of situations, both in academic and ordinary daily activities (Richardson & Suinn, 1972, p. 551).

Mathematics self-concept—a person's perceived ability to learn mathematics.

Performance in Mathematics—the level of attainment of mathematical skills, or knowledge, as measured by achievement tests, mathematical tasks, or grades in mathematics courses.

Advanced students—those students in Ontario who are following the curriculum required for university entrance.

CHAPTER II

LITERATURE REVIEW

Math Anxiety

Math anxiety seems to have grown out of the broader term "anxiety." Speilberger (1972) developed a theoretical model of anxiety, in which anxiety is divided into three interrelated forms: state anxiety, trait anxiety, and anxiety-as-process. State anxiety (referred to as "A-state") is an "unpleasant state or condition which is characterized by activation or arousal of the autonomic nervous system" (Speilberger, 1972, p. 482). State anxiety is time, and situation specific and is aroused when a situation is perceived as threatening or harmful. Trait anxiety is neither time nor situation specific. Speilberger describes it as a relatively stable personality trait, making one more prone to anxiety. Hence, a person who has high *trait anxiety* is more prone to experience state anxiety in a broader range of situations, and with greater severity than someone who does not have high trait anxiety. Through his model of anxiety-as-process, Speilberger explained anxiety as a result of a chain reaction that consisted of a stressor, a perception of threat, an A-state reaction, cognitive reappraisal, and coping.

Math anxiety, according to Cemen (1987), is an A-state reaction to mathematics-related situations perceived as threatening. Cemen claims that the most prominent threats associated with math anxiety are threats to self-esteem (see Fig. 1).

Stressor (involving math)	Perception of Threat to Self-Esteem	Mathematics Anxiety Reaction	Cognitive Reappraisal	Coping

Fig. 1 Model of Anxiety-as-process, specific to Mathematics Anxiety (from Cemen, 1987)

According to Cemen's model of math anxiety, "dispositional antecedents," "situational antecedents," and "environmental antecedents" interact to produce math anxiety with its physiological manifestations (e.g., perspiring, increased heart rate). Dispositional antecedents are factors contributing to the perception of threat. One example of this is math self-concept, which has been included as an element of this study. Situational antecedents "include the stressor and contextual factors surrounding it" (p. 8). These stressors only precipitate math anxiety if they are perceived as threats to self-esteem. Stressors may include classroom atmosphere, the way math is taught, and math tests. Environmental antecedents, like situational antecedents are "outside" the individual, and include elements such as parental encouragement. Situational and environmental antecedents were out of the scope of the current study.

The term "mathematics anxiety" was first popularized by Sheila Tobias (1976a) with her article "Math Anxiety: Why is a Smart Girl Like You Counting on Your Fingers?," in Ms. magazine. From the beginning math anxiety has been associated with females. Tobias described the panic, helplessness, paralysis, and mental disorganization that occurs in math anxious persons when they are required to solve mathematical problems. Boodt (1979) identified anxiety towards math as "a feeling of apprehension, out of proportion to any actual threat, which is experienced in reaction to a situation involving the use of mathematics" (p. 28). Wood (1988) referred to mathematics anxiety as "the general lack of comfort that someone might experience when required to perform mathematically" (p. 11). More commonly, math anxiety is defined by Richardson and Suinn (1972) as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551).

Indeed, math anxiety goes by many descriptions in the literature, from anecdotal quotes attributed to female students to precisely defined operational definitions, based on math anxiety scales. One prominent operational definition is associated with the Mathematics Anxiety Rating Scale (MARS) which was used in this study. Wahl (1984) identified two themes that emerge from different definitions of math anxiety in the literature: (a) Math anxiety involves feelings of panic when confronted with math, and (b) individuals who suffer from math anxiety often associate it with particularly memorable negative experiences.

Math Anxiety and Trait Anxiety

Guided by Speilberger's (1972) anxiety-as-process model, some researchers have investigated the relationship between trait anxiety, and math anxiety. Much of the work on math anxiety has been conducted using correlational statistics analysis. Correlational statistics analysis assumes that correlations that are close to 1 or -1 (mathematically speaking, correlations with an absolute value that is close to 1) are strong, and correlations close to 0 are weak. Betz (1978) studied a sample of 652 university students and found a moderate correlation (.42 to .48, $p < .01$) between math anxiety and the State-Trait Anxiety Inventory (STAI) (Speilberger, Gorsuch, & Lushene, 1970). Math anxiety was measured using the Mathematics Anxiety Scale, which is a subscale of the Mathematics Attitude Scale (MAS). McAuliffe (1986) reported a moderate correlation between the STAI and the MARS of .49 ($p < .0001$) in a study of 138 preservice teachers. Research tends to support the contention that those who are more prone to anxiety suffer from higher levels of math anxiety.

Richardson and Suinn (1972) reported that many people who do not suffer from trait anxiety do suffer from math anxiety. They reported that over one-third of the students requiring help for anxiety in a university counseling program indicated that math anxiety was the central focus of concern. These students did not suffer from trait anxiety. Further, Brush (1978) contended that math anxiety is different from trait anxiety in being more limited to quantitative situations.

Research investigating the relationship between math anxiety and trait anxiety indicates that the constructs are related by correlation, but research also implies that math anxiety and trait anxiety are distinct. The precise nature of the relationship between math anxiety and trait anxiety is not yet clear. As Reyes (1984) stated, "there seems to be some connection between mathematics anxiety and trait anxiety; however, this relationship has not been studied in depth" (p. 565), and it is not addressed in this study.

Math Anxiety and Test Anxiety

Some researchers view math anxiety as nothing more than subject specific test anxiety (Brush, 1981; Wahl, 1985; D'Ailly & Bergering, 1992), and they would argue that mathematical tasks, problems, and situations resemble test situations. Correlational studies between test anxiety and math anxiety seem to support this contention. In correlational studies, math anxiety is usually measured by either the Mathematics Anxiety Rating Scale (MARS) (Ricardson & Suinn, 1972), or the math anxiety subscale of the Mathematics Attitude Scale (MAS) (Fennema & Sherman, 1976). In the MARS, high scores correspond with high levels of math anxiety: A positive correlation between test anxiety and the MARS indicates that higher math anxiety accompanies higher test anxiety. In the MAS, high scores correspond with low anxiety: A negative correlation between the MAS and test anxiety imply higher math anxiety is linked to higher test anxiety.

Several researchers have found a moderate correlation between math anxiety and test anxiety. In a study involving 182 university students, Betz (1978) found a moderate correlation of -.42 ($p < .001$) between math anxiety, as measured by the MAS, and test anxiety, as measured by the Test Anxiety Inventory (TAI). McAuliffe (1986) found a similar moderate correlation, .43 ($p < .001$), between the MARS and the TAI in a sample of 138 preservice teachers. Hembre (1990) conducted a meta-analysis of 151 studies which used the MARS or MAS to assess math anxiety. The results of the analysis added further support for a correlational relationship between math anxiety and test anxiety. A moderate and statistically significant ($p < .01$) correlation, .52, was found between math anxiety and test anxiety.

However, the dimensions measured by the MARS include factors beyond test anxiety. Several researchers have conducted factor analyses of the MARS to determine its dimensionality. Factor analyses have consistently shown that test anxiety is a dominant factor of the MARS, supporting the claim that math anxiety is subject specific test anxiety. However, these analyses have also consistently found factors other than test anxiety. Although test anxiety appears to be an important aspect of math anxiety, the constructs are not interchangeable.

Three subsequent factor analyses suggest that evaluation anxiety is only one aspect of math anxiety as measured by the MARS.

1. Brush (1978) applied factor analysis to the MARS as part of an investigation into the validity of the measure. The factor analysis yielded two factors: Problem-Solving Anxiety, which was found to be the dominant factor, and Evaluation Anxiety. An example of Problem-Solving Anxiety would be anxiety about "Adding up 976 + 777." An evaluation component was identified in the MARS, but an additional factor, Problem-Solving Anxiety, was also found.

2. Rounds and Hendel (1980a) also examined the dimensionality of the MARS. Their purpose was to identify the undergirding dimensions of math anxiety as measured by the MARS. The sample consisted of 350 female students from a large midwestern university who were participating in a mathematics anxiety treatment program. Rounds and Hendel (1980a) derived a two-factor solution from their analysis. The first factor, which was found to be the dominant factor, was labeled Mathematics Test Anxiety. The second factor identified in the analysis was Numerical Anxiety. This factor was identified

through items that "refer to everyday, concrete situations requiring some form of number manipulation (such as adding and multiplying)"(Rounds & Hendel, 1980a, p. 142). Again, another factor was isolated in the MARS, along with the evaluation anxiety component.

3. Resnick et al. (1982) factor analyzed the MARS, and also found that test anxiety was not the only factor in the scale. The sample consisted of 1106 freshmen students at the University of Rochester. Three independent factors were isolated, which were labeled Evaluation Anxiety, Social Responsibility Anxiety, and Arithmetic Computation Anxiety. Evaluation Anxiety was the dominant factor. Social Responsibility Anxiety items involved being responsible for fiscal or arithmetic matters in organizations and clubs. Arithmetic Computation Anxiety items involved everyday situations requiring various forms of arithmetic manipulation. The results of this study also indicated that test anxiety is not the only factor within the MARS.

The Mathematics Anxiety Rating Scale for Adolescents (MARSA) was developed by Suinn and Edwards (1982) to measure math anxiety among adolescents. Like the MARS, the MARSA has been found to contain a test anxiety factor. As part of an investigation into the validity of the MARSA, Suinn and Edwards (1982) applied factor analysis to the MARSA in a study involving 1200 junior and senior high students. The analysis identified two factors: Numerical Anxiety, and Mathematics Test Anxiety.

Correlational studies of test anxiety and math anxiety indicate that they are related constructs when math anxiety is assessed using the MARS or the MAS. Factor analyses of the MARS and the MARSA support the notion that test anxiety is an important component of the instrument. However, test anxiety, although often the dominant factor, is not the only factor present in the MARS, or the MARSA. Hence, math anxiety and test anxiety cannot be considered as interchangeable constructs as some researchers have claimed.

Math Anxiety/Performance

Generally research has found that higher levels of math anxiety are linked with lower levels of performance; A correlational relationship between math anxiety and performance has been displayed across age groups (elementary to university students) (e.g., Richardson & Suinn, 1972; Suinn & Edwards, 1982; Thorndike-Christ, 1991; Tocci & Engelhard, 1991). The correlation remains significant among both females and males when various measurement scales of math anxiety and math performance are used (e.g., Ma, 1999). It appears that math anxiety functions in a similar fashion for both males and females with respect to performance for both university and preuniversity students, however research involving preuniversity students is not consistent (Hembree, 1990; Ma, 1999). Studies which investigate the math anxiety/performance relationship are summarized as follows. They are arranged in chronological order and separated according to the age of the participating students.

Studies of University Students

Richardson and Suinn (1972) set out to test the validity of the MARS. As part of the test of validity, the authors administered the MARS along with the Differential Aptitude Test (DAT) to 397 university undergraduates. The DAT is an assessment of mathematical problem solving. A moderate to high correlation of -.64 ($p < .01$) was found between the two measures: Higher math anxiety was accompanied by lower performance.

Betz (1978) examined factors related to the prevalence, nature and effects of math anxiety. She studied 652 university students (two mathematics classes and one psychology class), and found that high school mathematics preparation was more strongly correlelated with math anxiety than was performance. Nevertheless, math anxiety, as measured by the MAS, was moderately related to mathematics achievement test scores (The American College Test). The correlations were .40, and .22 ($p < .001$) for the math classes, and .34 ($p < .001$) for the psychology class. High scores on the MAS represent low anxiety, hence this study also shows that higher math anxiety is accompanied by lower performance.

Rounds and Hendel (1980b), using the MARS, also reported a significant correlation between math anxiety and performance in a sample of 124 female university students in a math anxiety treatment program. The researchers reported a moderate correlation of -.35 ($p < .001$), between the level of math anxiety and scores on an arithmetic test administered to university women. Rounds and Hendel found that test anxiety and self-estimated math ability were the most important variables in predicting math anxiety, but, math anxiety and high school mathematics preparation were most important in predicting arithmetic performance for university students. However, others have not had similar results. Resnick et al. (1982) discovered moderate to low correlations between math anxiety, as measured by the MARS, and performance, as measured by final grades in first year university mathematics. The study involved 555 first year students from the University of Rochester (ranging in age from 17 to 22) in math classes at 5 different levels. Statistically significant correlations ($p < .05$) were found in all classes except at the second highest level. Although, math anxiety was found to be significantly related to performance, Resnick et al. noted that the individual items on the MARS were not related in a linear fashion, and the scores themselves did not form a normal distribution as is required to treat MARS scores as interval data. Hence, the researchers concluded that "the data based on the MARS....have several limitations that suggest caution in the extent in which generalizations can be made from our findings" (p. 44).

Adams and Holcomb (1986) analyzed the relationship between math anxiety and performance in a sample of 92 students in an upper level college statistics course. Adams and Holcomb found correlations between mathematics anxiety; and Basic Mathematical Skills-Arithmetic (-.41), Basic Mathematical Skills-Algebra (-.45), and final grade in a statistics course (-.24). Again, higher performance was linked to lower levels of math anxiety. A canonical analysis produced one significant canonical factor explaining the relationship between math anxiety and performance. Variables having significantly high loading on this factor include: mathematics anxiety (.90), arithmetic skills (-.83), and algebra skills (-.64). The authors hypothesis an "interdomain" variable between mathematics anxiety and performance, which they termed "mathematics efficiency," that is, "those who are efficient in mathematics use their energy, time and skills in an effective manner,"(Adams & Holcomb, 1986, p. 947) and hence perform better.

Cooper and Robinson (1991) examined the relationship of math anxiety and performance, among other tasks, and found that math anxiety and performance were significantly related. Using a sample of 290 mathematics, science, and engineering undergraduate students from a public midwestern university The American College Testing Program: the Mathematics Academic Tests (ACT-Q), and the Missouri Mathematics Placement Test (MMPT) were used to measure performance. Cooper and Robinson found a .41 correlation between mathematics anxiety, as measured by the MAS, and scores on the ACT-Q; and between mathematics anxiety and the MMPT, correlation of .47 was reported. Both correlations were significant at the .0005 level. The MAS assessed math anxiety, hence the study illustrates that higher math anxiety is accompanied by lower performance .

From the literature on the relationship between math anxiety and performance among university students, it is clear that higher math anxiety is accompanied by lower performance, and that this relationship exists using a variety of measures for both performance and math anxiety.

Studies of Preuniversity Students

Studies involving preuniversity students show a similar relationship between math anxiety and performance as that found among university student. In validating the MARSA, Suinn and Edwards (1982) investigated the relationship between scores on the MARSA and grades received in mathematics using students in middle and high school. They concluded that high math anxiety, as measured by the MARSA, was associated with low mathematics course grades, supporting the existence of the relationship between math anxiety and performance among middle and high school students.

Similarly, Meece et al. (1990) examined math anxiety, performance, and enrollment intentions in a two-year longitudinal research project involving 250 students in grades 7 through 9. The Student Attitude Questionnaire (SAQ) (Eccles, 1983) measured math anxiety, and was administered to the sample in the spring of Year 2 of the study. Performance was assessed by math grades in Year 1, and Year 2. They reported correlations between each item on the SAQ measuring math anxiety and grades in Year 1, and Year 2. Eight out of the ten questions assessing math anxiety were found to have statistically significant ($p < .01$) moderate correlations with grades in both years and for both genders, that is, higher grades were accompanied by lower anxiety. The study provided additional support for the existence of a significant moderate relationship between math anxiety and performance, and that the relationship can be found using measures other than the MARS and the MAS.

Thorndike-Christ's (1991) study involving 722 male and 794 female middle and high school students, examined performance, and math anxiety, as measured by the MAS. Consistent with the above studies, a moderate relationship was found between math anxiety and performance, .47 ($p < .0001$). High scores on the MAS correspond to low math anxiety, hence the results indicate that higher math anxiety was accompanied by lower performance. The study included students in grade 10 "accelerated" math among the 1516 students in the sample, but only one aggregate score for math anxiety was reported.

Tocci and Engelhard (1991) used nationally representative samples of 13 year-old students from the United States (n=3846) and Thailand (n=3528) to analyze the relationship of affective variables related to learning mathematics with mathematics achievement, parental support, and gender. As part of the study, the researchers examined correlations between scores on the Second International Mathematics Study (SIMS), and math anxiety, which was measured by five items on a questionnaire created by the authors. Both measures were administered at the end of the 1981-82 school year. For the sample of students from Thailand, a correlation of -.14 ($p < .01$) was found, and in the United States the correlation was -.24 ($p < .01$). Again higher math anxiety was accompanied by lower performance. This study illustrates that the relationship between math anxiety and performance is not only present in university students, but also in preuniveristy students.

Meta-Analyses

Two meta-analyses reported that higher levels of math anxiety are linked to lower levels of performance, and that the relationship holds for both genders. But, the studies do not agree on gender differences in the strength of the relationship. Hembree (1990) conducted a meta-analysis of 151 studies "to scrutinize the construct math anxiety" (p. 33). One of the purposes of the study was to examine the relationship between math performance and math anxiety; 65 of the 151 studies employed in the meta-analysis examined this relationship. Among university students, a correlation of -.31 ($p < .01$) was found for the math anxiety and performance relationship. A correlation of -.34 ($p < .01$) was reported for students from grades 5 to 12 for the relationship. Interestingly, the relationship between math anxiety and performance, for studies involving grade 5 to 12 students, was significantly stronger for males, -.36, than for females,-.30, a difference that disappeared among college students. The meta-analysis provides strong support for the presence of a moderate relation between math anxiety and performance, and the existence of the relationship among both males and females. The study also indicates that the relationship between math anxiety between and performance may be higher among male than female preuniversity students; but that the gender differences in the strength of the relationship among university students are not significant.

Ma (1999) conducted a meta-analysis which focused on the relationship between math anxiety and performance in math among elementary and secondary students. Ma reported, after employing effect coding, that "the relationship between mathematics anxiety and mathematics achievement was similar for males and females" (p. 529), in contradiction to Hembree's (1990) findings discussed above. However, it appears that Ma's study is more generalizable to preuniversity students than Hembree's, since, as Ma noted, "it (Hembree's (1990) meta-analysis) was based on 58 studies on college students but only 7 studies on elementary and secondary students, (hence) Hembree's conclusions seem to apply more to college students than precollege students" (p 523).

Ma (1999) also found the common population correlation for the relationship between math anxiety and performance to be significant (-.27, $p< .05$), so that high math anxiety was linked to low performance. Ma used a series of general linear models to examine the major research design characteristics that determine variation among effect size. The results indicated that:

> the relationship between mathematics anxiety and mathematics achievement is

consistent across gender groups (male, female, mixed), grade-level groups (Grades 4 through 6, Grades 7 through 9, and grades 10 through 12), ethnic groups (mixed and unmixed), instruments used (MARS and others), and year of publication. (Ma, 1999, p. 531)

The literature clearly illustrates that higher math anxiety is accompanied by lower performance among preuniversity students(e.g., Suinn & Edwards, 1982; Meece, Wigfield, & Eccles, 1990; Thorndike-Christ, 1991; Tocci & Engelhard, 1991). The relationship was shown to exist using a variety of measures for both performance and math anxiety among both males and females(e.g., Meece, Wigfield, & Eccles, 1990; Ma, 1999). Research examining the gender difference in the strength of the math anxiety and performance relationship among preuniversity students have found conflicting results, but it appears that no gender difference exists: Math anxiety functions similarly for both males and females with respect to performance (Ma, 1999). No research, however, appears to examine the relationship among university bound students as did the current study.

Theoretical Explanations for the Relationship

Theoretical models of the relationship between math anxiety and performance are complicated to establish (Gliner, 1987; Meverech & Ben-Artzi, 1987), but researchers have demonstrated various characteristics of the relationship using both linear and curvilinear models.

Curvilinear Models

Ma (1999) discussed "arousal theory" as a possible framework by which to view the relationship. According to arousal theory, there is an optimal level of arousal, the reaction to anxiety, around the middle of the arousal measurement—optimal both in terms of performance and in being most pleasant. Lower levels of arousal do not provide maximal motivation to facilitate performance, and above the optimal level, anxiety interferes with performance. The idea implies a curvilinear relationship between math anxiety and performance (Ma, 1999). Hence, the theory indicates that some anxiety is beneficial to performance, but after a certain point it is detrimental.

The existence of a curvilinear relationship between math anxiety and performance can also be explained using Speilberger's (1972) model of anxiety-as-process (see "Math Anxiety" p. 8). According to Speilberger's model, coping with an A-state reaction—which occurs when there is a perception of a threat—can take on a variety of forms, "involving actions to combat the threat, inaction, or defense mechanism such as repression and rationalization" (Reyes, 1984, p. 564). When the arousal from the anxiety is relatively high, the individual may take positive action to reduce the unpleasant state, which often results in performance being facilitated. More frequently, however, the methods of coping decrease performance, or have a debilitative effect (Reyes, 1984). Hence, according to Speilberger's model, high to moderate levels of anxiety can facilitate performance, and other levels of anxiety may debilitate performance. This suggests that a curvilinear relationship between math anxiety and performance may exist. Despite the possibility of a curvilinear relationship, most researcher investigate linear models to explain the relationships through correlational studies (Ma, 1999). That is, correlational studies of the relationship between math anxiety and performance, by their nature, investigate the degree to which math anxiety and performance are linearly related.

Linear Models

Two theoretical models have been posed to explain the reported linear relationship between math anxiety and performance. Mandler and Sarason (1952), and Wine (1971) proposed an "interference" model, from which math anxiety may be viewed as a disturbance to the recall of prior mathematics knowledge and experience. As a result, high levels of math anxiety will result in low performance. Tobias (1985) developed a model in which math anxiety is viewed as the remembrance of poor mathematics performance in the past. She postulated that poor performance caused high math anxiety. Within Tobias's framework, low performance was due to poor study habits, and deficient test taking skills instead of math anxiety. Nevertheless, the theory accounts for the linear relationship between math anxiety and performance.

Math Self-Concept, Math Anxiety, and Performance

Just as math anxiety is a subset of anxiety, math self-concept is a part of "self-concept." Eccles (1983) defines self-concept "as the assessment of one's own competency to perform specific tasks or to carry out role-appropriate behaviors" (p. 82). Research typically reports a positive relationship between self-concept and general academic achievement (Brookover & Erickson, 1969; Covington & Berry, 1976; Felker, 1974; Purkey, 1970), suggesting that students with higher levels of self-concept also attained higher levels of academic achievement.

Math self-concept, that is, self-concept specific to math, is a person's own perceived ability to learn mathematics. Reyes (1984) stated that math self-concept, or confidence in learning math (terms which she uses interchangeably) "has to do with how sure a person is of being able to learn new topics in mathematics, perform well in mathematics class, and do well on mathematics tests" (p. 560). Researchers have consistently found that students with higher math self-concept have lower math anxiety and perform to a higher standard in math than those with lower math self-concept: characteristics which hold for males and females (e.g., Fennema & Sherman, 1978; Rounds & Hendel, 1980b; Dwinell & Higbee, 1991). Although some studies reported that the math self-concept/performance relationship was stronger than the math anxiety/performance relationship (e.g., Thorndike-Christ, 1991; Casey, Nuttall, & Pezaris, 1997) which would imply that math self-concept is more closely linked to performance than is math anxiety, other studies indicate that there is no significant difference (e.g., Rounds & Hendel, 1980b). A gender difference in the strength of the math self-concept/performance relationship has not been found (Sherman, 1979; Tartre & Fennema, 1995), indicating that math self-concept functions similarly for males and females with respect to performance.

The studies which investigate the relationships among math self-concept, math anxiety, and performance are summarized as follows. They are arranged in chronological order and separated according to the age of the participating students.

Studies of University Students

Rounds and Hendel (1980b) investigated the measurement and dimensionality of math anxiety. The study included a correlational analyses of math anxiety, measured with the MARS, and math self-concept measured by a subscale of the MAS, the CMAS. The sample consisted of 124 female students in a math anxiety treatment program at a large midwestern university. The researchers found statistically significant, moderate to high correlations for math self-concept/performance on the Arithmetic Placement Test (.25, $p < .01$), so that high math self-concept was linked to high performance; and for math anxiety/performance (-.35, $p < .001$), so that high math anxiety was accompanied by low math self-concept. The difference between the strength of the math anxiety/performance relationship, and the math self-concept/performance relationship was not significant.

In developing a scale for the measurement of math self-concept, Gourgey (1982) analyzed the relationship among her measure of math self-concept, math anxiety, and performance on a test of arithmetic skills. In a sample of 120 undergraduate and graduate students, a moderate to high correlation was reported for math anxiety/math self-concept (-.62, $p < .001$); between math self-concept and scores on the arithmetic test (.36, $p < .001$); and between math anxiety and the arithmetic test (-.28, $p < .05$). Again, higher math anxiety was found to accompany lower math self-concept; and higher math self-concept was linked to higher performance. The difference in the strength of math self-concept/performance relationship, and the math anxiety/performance was not significant.

Hackett and Betz (1989) investigated the relationship among math self-concept, math anxiety, and performance. Performance was measured with the Mathematics

Problems Performance scale (MPPS), and the American College Test Mathematics (ACT-M); and the CMAS assessed math self-concept in a sample of 262 university students. Further, the Mathematics Anxiety Scale (Betz, 1978) measured math anxiety. Again, a moderate to high relationship was found for math self-concept/performance (.43, $p < .01$ with respect to the MPPS; and .57, $p < .01$ with respect to the ACT-M), so that higher math self-concept accompanied higher performance. A stronger relationship was reported for math self concept/performance, than for math anxiety /performance (.40, $p < .01$ with respect to the MPPS; and .45 with respect to the ACT-M), although it was not indicated whether or not the difference was significant.

In a study involving 20 male and 38 female university students, Dwinell and Higbee (1991) examined affective variables related to performance in math. The researchers discovered very high significant correlations for math anxiety/math self-concept of -.87 and -.91, for males and females respectively, but the gender difference in the strength of the relationship was not significant. The CMAS was used to measure math self-concept and math anxiety was assessed with the MAS. The generalizability of the high correlations, however, between math anxiety and math self-concept is questionable due to the small sample size. But, other researchers using larger samples have found very high correlations for math anxiety/math self-concept. Pajares and Miller (1994), for example, discovered a very high statistically significant ($p < .0001$) correlation of -.87 between math self-concept and math anxiety in a sample of 350 university students, in which lower math anxiety was linked to higher math self-concept. The CMAS was used to assess math self-concept, and the MAS was used to measure math anxiety. The researchers found the math self-concept/ performance relationship (.54, $p < .0001$) to be stronger than the math anxiety/performance relationship (.51, $p < .0001$), but the difference was not statistically significant.

In Hembree's (1990) meta-analysis of 151 studies related to math anxiety the math anxiety/math self-concept relationship was highly statistically significant ($p < .01$) correlation (-.71). This study again indicates that higher math anxiety is accompanied by lower math self-concept.

Summary.

Literature has generally found that higher math self-concept is accompanied by lower math anxiety, and higher performance among university students (e.g., Gourgey, 1982; Hackett & Betz, 1989). Further, higher math self-concept is typically linked to lower math anxiety (e.g., Pajares & Miller, 1997). Generally, studies have found math self-concept to be more closely linked to performance than is math anxiety (e.g., Thorndike-Christ, 1991; Casey, Nuttall, & Pezaris, 1997), with the exception of Rounds and Hendel (1991) who found no significant difference in the strength of the math anxiety/performance relationship, and the math self-concept/performance relationships. Finally, the strength of the math self-concept/performance relationship seems not to differ by gender, indicating that math self-concept functions in a similar fashion for both genders with respect to performance, although only Dwinell and Higbee (1991) investigated gender differences in this relationship.

Studies of Preuniversity Students

Fennema and Sherman (1977a) examined the math self-concept/performance relationship. Math self-concept was measured with the CMAS, and performance was measured by the Test of Academic Progress (TAB). The sample consisted of 589 female, and 644 male grade 9 students through grade 12 students at four different schools. Students who were identified as functioning below the grade level in math in which they were enrolled were excluded. Math self-concept was found to have moderate correlations with performance in all grades and both genders, except for grade 12 males for whom the correlation was low and not statistically significant. The correlations for males (grades 9 to 11), was .40, and for females (grades 9 to 11) it was .41 ($p < .01$); The correlations for males and females in grade 12 were .22 ($p < .05$), and .47 ($p = .01$) respectively. Hence, higher math self-concept was accompanied by higher performance for both genders. The gender difference for the above correlations was not significant, indicating that math self-concept functions in a similar fashion for both genders with respect to performance.

Fennema and Sherman (1978) used a sample of grades 6 through 8 students (N=1320) in a follow up study. Math self-concept was measured with the CMAS, and performance assessed using the Romberg-Wearne Problem Solving Test (R-W). The R-W provides a score for Comprehension (R-W C), Application (R-W A), and Problem Solving (R-W P). Moderate and significant ($p < .01$) correlations were found between math self-concept and all four subscales of the R-W, for both genders. The correlation coefficients found between math self-concept and the R-W C were .26 for females and .33 males; .33 (females) and .38 (males) between math self-concept and the R-W A; and between math self-concept and the R-W P correlations of .34 (females) and .42 (males) were reported. Again, higher math self-concept was accompanied by higher performance for both males and females. Statistical significance of gender differences in the strength of the math self-concept/performance relationship was not reported.

Sherman (1979) performed a correlational analysis of performance and math self-concept (n=305). The CMAS measured math self-concept and was administered to students in their grade 9 year, which was correlated with marks in grade 10 and 11 math. Significant ($p < .05$) moderate correlations were found between math self -concept and grades for both males and females. In grade 11 the correlation was .29 for females, and .15 for males, and in grade 10, correlations were .39, and .19 for females and males respectively. Among grade 10 and 11 students, the relationship was not significantly stronger for either gender. These findings indicating that math self-concept functions similarly for males and females with respect to performance.

Eccles (1983) examined the math self-concept/performance relationship in a sample of students in grades 5 through 12 (n=668). The study took place over two years. The Student Attitude Questionnaire measured math self-concept in the first year, and performance was assessed by grades in math in the first and second years. Statistically significant ($p < .01$) moderate to high correlations were found for math self-concept/performance in both years, for both genders.

Thorndike-Christ (1991) examined the relationship of affective variables to performance in a sample of junior and high school students (722 male, 794 female). Again a highly significant ($p < .0001$) correlation of .85 was found for math anxiety/math self-concept. The CMAS was used to assess math self-concept, and the MAS to assess math anxiety, indicating that higher math self-concept is linked to lower math anxiety. The relationship between math self-concept and final grades was found to be statistically significant with a moderate to high correlation (.53, $p < .0001$) as was that for math anxiety/performance (.47, $p < .0001$). The strength of the correlation for math self-concept/performance was statistically significantly stronger than for math anxiety/ performance. The study included students in grade 10 "accelerated" math among the 1516 students in the sample, however only one aggregate score for math self-concept was reported for males and females.

As part of longitudinal study that followed a sample of 60 students as they progressed through grade 6, 10, and 12, Tartre and Fennema (1995) examined the relationship among performance, math self-concept, and math anxiety. Tartre and Fennema (1995) calculated correlation coefficients for each grade, and gender between math self-concept and performance (in grade 6 math performance was measured by the Mathematics Concepts Test, in grade 8 and 12 by the Sequential Test of Educational Progress, and in grade 10 by the Test of academic progress). The authors argue that "examining the correlations....showed a strong pattern of positive correlations between mathematics achievement and confidence for both males and females" (p. 210). Indeed, of the 32 correlations calculated, 27 were moderate to high, and statistically significant ($p < .05$). The researchers also concluded that no significant gender differences exist in the math self-concept/performance relationship for any grade, including grade 10. However, the absence of a significant gender difference in this relationship may be attributed to the small sample size (n=60) used in the study.

Casey et al. (1997) examined the relationship between gender and performance on the Mathematics Standardized Aptitude Test (SAT-M) on a sample of high school students (51 females, 43 males). The researchers described the sample as higher ability, college bound students, comparable to the students participating in the current study. Included in the study were two affective variables, math anxiety and math self-concept because, Casey et al. (1997) asserted, "research shows that children's expectancies about their success (self-confidence and anxieties) relate most strongly to their subsequent achievement" (p. 670). Again, a moderate statistically significant ($p < .01$) correlation was found between math self-concept and SAT-M performance (.590), which was significantly stronger than the math anxiety/performance relationship (.199). And, a statistically significant moderate correlation was found for math anxiety/math self-concept (-.447, $p < .01$). Math anxiety was assessed using a scale cited in Wigfeild and Meece (1988), and math self-concept was measured by an instrument cited in Parsons et al. (1980).

Summary

Literature investigating the relationship among math anxiety, math self-concept, and performance among preuniversity students has reported results generally consistent with those involving university students. Studies have typically found that higher math self-concept are accompanied by lower math anxiety, and higher performance; this relationship has been found among males and females (e.g., Fennema & Sherman, 1977a; Eccles, 1983; Tartre & Fennema, 1995). The studies of Thorndike-Christ (1991) and

Casey et al. (1997) found the strength of the math anxiety/performance relationship to be significantly greater than the strength of the math self-concept/performance relationship. Hence, math self-concept appears to be more closely linked to performance than is math anxiety.

Research investigating gender differences in the math self-concept and performance relationship have typically shown that math anxiety and math self-concept function similarly for both genders with respect to performance (Fennema & Sherman, 1977a; Sherman, 1979; Tartre & Fennema, 1995). The current study focused on these relationships with attention paid to the possibility of gender differences.

Theoretical Explanations for the Relationships

A conceptualization of the relationship between math self-concept and math anxiety comes from Cemen's (1987) model of math anxiety discussed previously (see "Math Anxiety," p. 8). Cemen described math anxiety as an A-state reaction to math-related situations that are perceived as threatening to self-esteem. Factors contributing to the perception of threat were called dispositional antecedents. Cemen argued that low math self-concept, which is a dispositional antecedent, functions to heighten the perception of threat in situations involving math, causing greater levels of math anxiety on a more frequent basis.

A theoretical explanation of the relationship between math self-concept and performance arises out of the literature concerning "math self-efficacy." Although similar, math self-efficacy should be considered as distinct from math self-concept (Hackett, 1985). Math self-concept differs from math self-efficacy. Math self-efficacy is a context specific assessment of competence to perform a specific task, or a judgement of one's capabilities to execute specific behaviors in specific situations. Math self-concept "addresses a more generalized or global confidence in one's ability to learn math" (Hackett & Betz, 1989, p. 262). It is a general assessment of students' perceived math capabilities in non-specific tasks or situations.

Examining the theory from which self-efficacy arose can facilitate an understanding of the math self-concept/performance relationship. The construct "self-efficacy" grew out of Bandura's (1986) "Social Learning Theory." Bandura (1982) contends that judgements of self-efficacy—perceived ability to successfully execute courses of action required to deal with prospective situations (p. 122) "whether accurate or faulty....determine how much effort people will expend and how long they will persist in the face of obstacles or aversive experiences" (p. 123). According to this theory, in the face of obstacles, people with low judgement of self-efficacy slacken their efforts or give up altogether, whereas those with a strong sense of self-efficacy persist, and exert a greater effort to master the challenge (Bandura & Schunk, 1981; Brown & Inouye, 1978; Schunk, 1981). Hence, those with strong judgement of self-efficacy produce high performance attainments (Bandura, 1982).

Taking a broader view of Bandura's Social Learning Theory, low math self-concept may lead individuals to apply less effort to tasks within mathematics, whereas those with a strong sense of math self-concept persist, and exert a greater effort to master problems, concept, and skills in math. Hence, according to this model, low math self-concept will lead to low performance.

Gender Differences in Math Anxiety and Math Self-Concept

Math Anxiety and Gender

Studies of University Students

Research on the relationship between math anxiety and gender among university students is not consistent. Some research identifies significant gender gaps in math anxiety, while other studies illuminate little or no gender gap. In validating the MARS, Richardson and Suinn (1972) compared females and males in terms of mathematics anxiety. In a sample of 397 university students, their analyses showed significant gender differences, though the sample was eighty percent female. Ohlson and Mein (1977) looked at gender differences in math anxiety among a sample of university students in both mathematics and non-mathematics majors. The researchers found that males and females did not differ in the amount of math anxiety experienced, irrespective of major. Brush (1976, 1978) conducted two studies involving gender and math anxiety using different samples from the same university. Brush discovered a significant gender difference in the first study which involved 109 university students. In the second study, based on 80 students from the same university, no gender difference was found. Through further inquiry, Brush determined that, in the first sample, males had studied math for a significant number of years more than females, but that there was no significant difference in the math background between males and females in the second sample. Commenting on the examination of these two studies, Richardson and Woolfolk (1980) point out that the "finding strongly suggests that amount of interaction with math, not the variable sex, predicts level of mathematics anxiety in college students" (p. 280).

Resnick et al. (1982) examined the gender differences in math anxiety as part of a study on the prevalence and dimensionality of math anxiety. Their sample consisted of 1106 university students in five different levels of math courses. The researchers found no large gender differences on the MARS for either the total sample or within course levels. Resnick et al. entertain the possibility that the absence of a gender gap may have been due to the fact that women in the study had extensive backgrounds in high school math, and had done well on achievement test. However, they observe that even in the lowest level course, in which students were less well prepared than students in other courses, there was no gender gap in math anxiety. Hence, this study indicates that background in math might not mediate the relationship between math anxiety and gender.

Llabre and Suarez (1985) also examined the relationship between gender and math anxiety. The sample consisted of 184 university students. Llabre and Suarez found that scores on a revised version of the MARS were significantly different between males and females, and concluded that "sex differences in math anxiety level cannot be completely explained on the basis of differential course-taking, since the men in our sample reported having taken approximately the same number of math courses in high school as did women" (p. 286). Based on this study, gender differences in math anxiety cannot be completely accounted for by differential math backgrounds.

Hembree (1990) examined gender differences in math anxiety in his meta-analysis of 151 studies with samples ranging from grade 5 student through to university. The authors report that, across all grades, female students reported higher levels of math anxiety than males. Hembree notes, however, that math anxiety seemed to have a more negative effect on performance in males than in females. To explain this phenomena, Hembree suggested that females may be more willing than males to admit their anxiety, or females may cope better with anxiety.

Literature concerning the relationship between gender and math anxiety provides varying findings. Some of the research shows a significant gender gap in mathematics anxiety with females experiencing higher levels (e.g., Richardson & Suinn, 1972; Brush, 1976; Hembree, 1990). In such cases, researchers have tended to explain the gender gap as being affected by mathematic background. However, other studies in which math background was controlled among males and females, have reported a gender gap in math anxiety (Rescick, Viehe, & Sanford, 1982; Llabre & Suarez, 1985).

Studies of Preuniversity Students

Studies involving preuniversity students, like those among university students, report varying findings. Wigfield and Meece (1988) studied math anxiety among 564 6^{th} through 12^{th} grade students. One of the purposes of the study was to assess age and gender differences in math anxiety. Using the Math Anxiety Questionnaire, the researchers found that, while both females and males answered the items representing mathematics anxiety in similar ways and were equally concerned about succeeding in math, females reported significantly more math anxiety than males. These differences were strong for females at all grade levels and were statistically significant at four of the seven grade levels. The difference was not significant among grade 10 students, the grade level of the students participating in the current study. Wigfield and Meece state that "...girls' stronger negative affective reactions to math might mean that as math courses get harder, they will be more likely to stop taking math when they have the option" (p. 215).

Tocci and Engelhard (1991) studied the relationship of attitudes toward math with math achievement, parental support, and gender among a sample of 13 year old students from the United Stated (n=3528), and Thailand (n=3846). For both samples, Tocci and Engelhard reported small, but significant gender differences in math anxiety. Further, the results of multivariate analysis showed that gender differences were significant even when controlled for performance and parental support.

In a study involving 191 grade 12 students from Saskatchewan, and 134 grade 12 students form Western Australia, Randhawa (1994) examined students' attitudes and performance in math. In both sample, Randhawa, using the Mathematics Attitude Inventory, found that females experienced significantly more math anxiety than males. The study is noteworthy since it illustrates a gender gap in math anxiety among a sample of Canadian high school students.

Satake and Amato (1995) also included an analysis of gender differences in math anxiety in their study on math anxiety and performance. Again, significant gender differences were reported in Mathematics Anxiety Rating Scale for Elementary School Students scores using a sample of 154 grade 5 and 6 Japanese students.

Although many studies involving preuniversity students report that females experience more math anxiety than males, several studies have found that there is no gender gap in math anxiety. Wahl (1985) examined gender differences in math anxiety among two groups of grade 9 students. The first group (n=37) were "above average," and the second group (n=22) were "average." Above average students were those who scored above average on a math placement test, and average students scored roughly average on the test. No significant gender difference was reported in math anxiety in either group, although the small size of the sample makes the generalizability of the results questionable. It was noteworthy that males and females were found to experience similar levels of math anxiety among above average ability high school students—a sample which could be considered comparable to advanced students in Ontario.

Gressard and Loyd (1987) investigated the effects of math anxiety and gender on computer attitudes, in a study involving 161 junior high and high school students. As part of the study, the authors examined gender differences in math anxiety, but found no significant gender differences.

Kelly (1994) examined differences in attitudes towards math between streamed (homogeneous ability groups) (n=275), and destreamed (heterogeneous ability groups) (n=151) grade 9 students from Central Ontario. She found no gender difference in either group.

The findings of studies investigating gender differences in math anxiety among preuniversity students are inconsistent. Some studies report that females experience more math anxiety than males (Wigfield & Meece, 1988; Tocci & Engelhard, 1991), while other studies report no gender difference (Gressard & Lloyd, 1987; Kelly, 1994). Since results of studies investigating gender differences provide varying findings, and since most studies involve heterogeneous ability samples outside of Ontario, the current study explored gender differences among advanced students in Northwestern Ontario.

Math Self-Concept and Gender

Studies of University Students

Studies examining gender differences in math self-concept among university students tend to report that males and females have similar levels of math self-concept. Dwindell and Higbee (1991) examined, in part, gender differences in math self-concept among 58 university students enrolled in first year algebra. Using the CMAS, no significant gender difference was found in math self-concept.

As part of a larger study involving 350 university students enrolled in a Faculty of Education, Pajares and Miller (1994) examined the relationships between gender and math self-concept. Using the CMAS to assess math self-concept, Pajares and Miller, consistent with the previous study, found that the mean score of females was less than that of males for math self-concept, but t-test revealed that the difference was not statistically significant.

Rogerson (1978) investigated the relationship between math self-concept, and other affective variables related to learning math in a sample of university students. Rogerson found that females had higher levels of math self- concept than males.

Studies of Preuniverstiy Students

Studies examining math self-concept and gender among preuniversity students have produced conflicting results. Fennema and Sherman (1977a) explored gender differences in math-self concept among a sample of 589 female, and 644 male grade 9 through grade 12 students at four different schools, using the CMAS to measure math self-concept, and performance was measured by the Test of Academic Progress (TAB). The study excluded those students who were identified as functioning below the grade level in math in which they were enrolled. Fennema and Sherman, based on statistically significant ($p < .05$) results on an analysis of variance (ANOVA), reported that math self-concept "...was significantly higher in males than females at three schools and tended to be higher in the fourth school" (p. 67).

In a follow-up study using a sample of grades 6 through 8 students (n=1320), Fennema and Sherman (1978) again employed the CMAS to assess math self-concept. Similar to the previous study, the bottom 15% of students by ability were omitted from the study. Using ANOVA, Fennema and Sherman (1978) found statistically significant ($p < .05$) gender gaps in math self-concept in grades 8 through 10, with the largest gap being in grade 10. In addition, inspection of the graph of the variable "math self-concept" by the variable "grade" presented by Fennema and Sherman (1978), indicates that math self concept decreases with grade, since the slope of the graph tends to be negative.

Eccles (1983), as part of a two year longitudinal study, examined gender differences in math self-concept in a sample of students in grades 5 through 12 (n=668). The Student Attitude Questionnaire measured math self-concept in the first year. Eccles

(1983), after performing an ANOVA, found that males had higher math self-concept than females, and the result was statistically significant (p< .01). Further, Eccles (1983), consistent with the conclusions of Fennema and Sherman (1978), asserts that "for....(math self-concept), there was a consistent downward linear trend as a function of grade level, with females preceding the males" (p. 103). The claim seems to be supported by a visual inspection of a graph illustrating the variable "math self-concept" by the variable "grade," in which the slope tends to be negative, indicating that math self-concept is decreasing with grade.

Thorndike-Christ (1991) examined gender difference in math self-concept among a sample of junior and high school students (722 male, 794 female). The CMAS was used to assess math self-concept. Thorndike-Crist (1991), after conducting an analysis of variance (ANOVA) on the male and female mean of math self-concept, reported that gender differences in math anxiety and math self-concept were found to be statistically significant (p< .0006) in that females tended to have lower math self-concept than males. The study included students in grade 10 "accelerated" math among the 1516 students in the sample, however, only one aggregate score for math self-concept was reported for males and females.

Although some studies have found a significant gender difference between math self-concept, others have not. As part of longitudinal study that followed a sample of 60 students as they progressed through grade 6, 10, and 12, Tartre and Fennema (1995), among other tasks, examined gender differences in math self-concept using the MAS. And, although the mean for math self-concept, as measured by the MAS, was higher for males than females in all grade, a t-test revealed that the results were not significant.

Felson and Tudeau (1991), as part of a larger study, examined gender differences in math self-concept, in a sample of students in grades 5 through 12 (elementary and middle school students, n=338; grade 12 students n=255). No gender difference in math self-concept was found. The researchers conclude that "the hypothesis that boys have more self-confidence about mathematics is not supported. Girls attribute as much mathematical ability as do boys" (p. 120).

Research examining math self-concept and gender among preuniversity students presents inconsistent results, in which some studies indicate finding a gender gap (males reporting higher math self-concept than females) (Fennema & Sherman, 1978; Eccles, 1983; Thorndike-Christ, 1991), while others report no significant difference (Felson & Trudeau, 1991; Tartre & Fennema, 1995). Although Fennema and Sherman (1977a, 1978) excluded lower ability students in their studies, most studies appear to use heterogeneous samples. It would be valuable to further explore gender differences among advanced students before they have been segregated out of mathematics altogether by course choices.

Studies involving university students typically report that there is no gender gap in math self-concept (Dwinell & Higbee, 1991; Pajares & Miller, 1994). Rogerson (1978), however, found that females university students had higher math self-concept. It appears that there may be a shift in the results from studies among preuniversity students to studies involving university students. It is possible that fewer females with low math self-concept have enrolled in math courses in university. This would be reasonable as students who have low math-self concept are less likely to choose to study mathematics when it becomes optional (Wigfeild, Meece, & Eccles, 1990), as it does for students in Ontario after grade 10. Hence, it was important to examine the gender gap in math self-concept, to determine if there is a gender gap in math self-concept among advanced grade 10 students in Northwestern Ontario. Should females have lower math self-concept than males, intervention programs must be implemented in, and before grade 10 to ensure that females have an equal opportunity to pursue math related-careers.

Theoretical Explanations for Gender Differences in Math Anxiety and Math Self-Concept

Fennema and Sherman (1977b) argued that stereotyping math as a male domain affects both females' performance in math, and the amount of math that females will choose to pursue in high school and university. They concluded that:

> There is....an accumulation of evidence that points to the conclusion that sexual stereotyping mathematics as a male domain operates through a myriad of subtle influences from peer to parent and within the girl herself to result eventually in the fulfilment of the stereotyped expectation of a "female head that's not much for figures." (p.371-372)

Tobias (1976b) contended that math anxiety results from "a culture that makes mathematics ability a masculine attribute" (p. 551). Research, however, does not support this theory. Llabre and Suarez (1985) found no significant relationship between math as a male domain and math anxiety in a study involving 112 female university students.

Similarly, Rounds and Hendel (1980b), in a sample of 124 female university students, discovered no significant correlation between math anxiety and math as a male domain, concluding that "for these female participants (of the study) there is no necessary link between the perception of mathematics as a male domain and mathematics anxiety" (p. 88). Of course, by this time math anxiety may have discouraged females from participation in math related subjects.

Research of younger students suggests that females' perceptions of math as a male domain are linked to math self-concept. In a longitudinal study of grade 8 to 11 students, Sherman (1980) found that perceiving math as a male domain predicted higher levels of math self-concept in girls, but not in boys. Hence, this study indicated that perceiving math a male domain is related to lower math self-concept in females, and not in males. Rounds and Hendel (1980b), although not finding a significant correlation between math anxiety and math as a male domain, reported a significant relationship (.2, $p < .05$) between math self-concept and math as a male domain in a sample of university women. Based on these studies, it appears that perceiving math as a male domain is related to math self-concept in females and, hence, may contribute to a gender gap in math self-concept, but does not likely contribute to gender differences in math anxiety.

Richardson and Woolfolk (1980) suggested that math anxiety is not related to gender, but rather is due to one's preparation in math, regardless of gender. These researchers asserted that if females experience more math anxiety than males, than it a result of their weak math backgrounds compared to males. Research, however, does not support this contention. Several studies in which math background was controlled among males and females, have reported a gender gap in math anxiety (Rescick, Viehe, & Sanford, 1982; Llabre & Suarez, 1985).

Several researchers have hypothesized that a response bias may account for gender differences in math anxiety (Meece et al., 1982; Hunsley & Flessati, 1988). Flessati (1990) pointed to the research of Nolen-Hoeksema (1987) investigating depression among males and females. Nolen-Hoeksema stated that the gender differences in the reporting of symptoms of depression may be a result of males' "unwillingness to admit to and seek help for depressive symptoms" (p. 266). Flessati tested the hypothesis that a similar response bias was operating for math anxiety using a sample of 124 first year psychology students from Lakehead University. Although females were found to experience significantly more math anxiety than males, Flessati reported that a response bias did not exist between males and females. Her study suggests that a response bias may not account for gender differences in math anxiety.

Differences in student-teacher classroom interactions among female and male students seems to be a plausible source of explanation accounting for gender differences in math self-concept. The American Association of University Women (1991) examined literature concerning differences in classroom interactions, and concluded:

> Whether one looks at preschool classrooms or university lecture halls, at female or male teachers, research spanning the past twenty-five years consistently reveals that males receive more teacher attention than do females. In preschool classrooms boys receive more instructional time, more hugs, and more teacher attention. The pattern persists through elementary school and high school. (p. 68)

The findings of the AAUW (1991) report were echoed in the study on classroom interactions conducted by Fennema and Leder (1990). Fennema and Leder concluded that "it is relatively easy to identify differential teacher interactions with girls and boys; In particular, teachers interact more with boys than girls, praise and scold boys more than girls, and call on boys more than girls" (p. 87).

Others have found that math self-concept appears to be related to classroom interactions. Parsons et al. (1982) studied 17 mathematics classrooms in Grades 5, 6, 7, and 9. They reported that high math self-concept was predicted, in part, by patterns of student teacher interactions. Students with higher math self-concept tended to have a higher proportion of interactions yielding praise, and higher incidences of work criticism after a student-initiated question, and less public feedback after a public error than a student with lower confidence. Thus, it seems that student teacher classroom interactions are different for males and females such that males get more attention and instructional time, and that increased attention and instructional time are linked to higher math self-concept. It is therefore plausible that gender differences in classroom interactions account for gender differences in math self-concept.

Summary

For the past three decades the relationship among math anxiety, math self-concept, and performance has received considerable attention. The findings which have emerged out of this research, as described in the literature review, are partitioned into two groups: characteristics of the relationship that are well established, and findings that are still in question.

Well Established Findings

1. Research has generally found that higher levels of math anxiety are accompanied by lower levels of performance; this relationship has been found in elementary through university students, and among males and females, using various measure of math anxiety, and performance (e.g., Richarson & Suinn, 1972; Suinn & Edwards, 1982; Hembree, 1990; Tocci & Engelhard, 1991; Thorndike-Christ, 1991; Ma, 1999).

2. Research has consistently reported that higher levels of math anxiety are linked with lower levels of math self-concept, among university and preuniversity students; this relationship holds for both genders (e.g., Fennema & Sherman, 1978; Rounds & Hendel, 1980b; Dwinell & Higbee, 1991).

3. Higher levels of math self-concept are consistently accompanied by higher performance; this relationship has been established among males and females, using a variety of performance measures (e.g., Fennema & Sherman, 1977a; Eccles, 1983; Tartre & Fennema, 1995).

4. Several studies have investigated the relative strength of the math self-concept/performance relationship for males and females. The studies have consistently found no gender differences in the strength of the relationship for both university and preuniversity students (e.g., Fennema & Sherman, 1977a; Sherman, 1979; Dwinell & Higbee, 1991; Tartre & Fennema, 1995).

5. Math self-concept has typically been found to be more closely linked to

performance than is math anxiety for both university and preuniversity students (e.g., Thorndike-Christ, 1991; Casey, Nuttal, & Pezaris, 1997).

One of the aims of the current study was to test the reliability of these findings among grade 10 advanced students in Northwestern Ontario. Grade 10 is the last year in which students in Ontario must take math. These relationships have not been established among university bound, advanced, high school students. Math anxiety, math self-concept, and performance have been shown to predict enrollment intentions in math beyond required courses, and aspirations of pursuing a math-related career (Wigfeild, Meece, & Eccles, 1990). Establishing the above listed aspects of the relationship among math anxiety, math self-concept, and performance will act as a catalyst to the development and implementation of prevention and treatment programs for math anxiety, and low math self-concept.

<u>Findings in Question</u>

1. It appears that the strength of the math anxiety/performance relationship is similar among male and female grade 10, and other preuniversity students, as was indicated by the meta-analysis of Ma (1999). However, the meta-analysis of Hembree (1990) found the relationship to be stronger among female than male students in this age range.
2. Studies typically report that math self-concept is more closely linked to performance than is math anxiety (e.g., Thorndike-Christ, 1991; Casey, Nuttal, & Pezaris, 1997). However, few studies have investigated this relationship among males and females separately. More studies are

required to establish this characteristic of the relationship, especially within each gender.

3. Research investigating gender differences in math anxiety have produced conflicting results for both university and preuniversity students: some research reports that females experience higher levels of math anxiety than males (e.g., Richardson & Suinn, 1972; Satake & Amato, 1995), while other studies report that there is no significant difference (Llabre & Suarez, 1985; Kelly, 1994).

4. Studies examining gender differences in math self-concept involving preuniversity students have reported conflicting findings. Some report a gender gap with males reporting higher math self-concept than females (Fennema & Sherman, 1978; Eccles, 1983; Thorndike-Christ, 1991), while others report no significant difference (Felson & Trudeau, 1991; Tartre & Fennema, 1995). Studies involving university students typically report that there is no gender gap in math self-concept (Dwinell & Higbee, 1991; Pajares & Miller, 1994). Rogerson (1978), however, found that females university students had higher math self-concept.

Most of the findings in the relationship among math anxiety, math self-concept, and performance which are in question involve gender. To ensure equity in mathematics, it is crucial to determine if math self-concept or math anxiety are more closely linked to performance among females than males, particularly in grade 10, which is the last year that students in Ontario must take math. As has been discussed earlier, performance is a strong predictor of enrollment intentions of students in math-related courses and careers.

Hence, if math anxiety or math self-concept is more closely linked to performance among males than females, programs must be implemented to bolster math self-concept and reduce or prevent math anxiety in grade 10 and earlier.

Compounding the possible gender inequity in math education, related to math anxiety and math self-concept, is the question of a gender gap in these areas. Should females have lower math self-concept or higher math anxiety, there is still greater urgency to develop and implement programs that combat high math anxiety and low math self-concept in females in grade 10 and in earlier grades.

CHAPTER III

METHODOLOGY

Sample

The sample consisted of 320 grade 10 advanced students from two school boards in Northwestern Ontario. There were 141 students (57 female, 84 male) in the first school board, and 178 students (117 female, 60 male) in the second. The schools in each school board were chosen using random sampling, and all grade 10 advanced classes were used in each chosen school. All students approached about participating in the study agreed to fill out the questionnaires. Two students filled out the questionnaires incorrectly. These two questionnaires were not included in the study.

Independent and Dependent Variables

The dependent and independent variables differ depending upon the particular analysis being performed. When examining the math anxiety/performance, math self-concept/performance, and math anxiety/math self-concept (see "Research Questions" 1, 2, 3, and 4), performance is the dependent variable, and math anxiety and math self-concept are the independent variables.

When determining whether there is a gender difference in the strength of the math anxiety/performance relationship, or the math self-concept/performance relationship; and to determine if there is a gender gap in math anxiety or math self-concept (see "Research Questions" 4, and 5), gender is the dependent variable, and math self-concept and math anxiety and are the independent variables.

Instruments

Mathematics Anxiety Rating Scale for Adolescents (MARSA)

The Mathematics Anxiety Rating Scale for Adolescents (MARSA; see Appendix E) will be used to measure math anxiety. The instrument is a 98-item five-point Likert-type scale (responses range from 1=not at all to 5=very much). Scores range from 98 to 490, where higher scores represent higher levels of math anxiety. The MARSA is a modified version of The Mathematics Anxiety Rating Scale (MARS) which was developed in Richardson and Suinn in 1972 to measure math anxiety which they described "as feeling of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of situations, both academic and ordinary daily activities" (p. 551). The MARSA was developed in 1982 by Suinn and Edwards to measure math anxiety among adolescents. Suinn and Edwards state that "the MARSA is a revised form of the MARS that involves changes in some words or the substitution of new items appropriate for adolescent" (p. 577).

A factor analysis of the MARSA indicated that instrument assesses two factors: Numerical Anxiety, and Mathematics Test anxiety (Suinn & Edwards, 1982). Examples of questions that assess Mathematics Test Anxiety include "Thinking about an upcoming math test five minutes before," and "Taking an examination in a math course." Questions which assess Numerical anxiety include "Hearing friends quote the odds on a game as they make bets," and "Picking up a math textbook to begin a difficult reading assignment."

Reliability

Using a sample of 1780 middle school, and high school students, Suinn and Edwards found the MARSA to have a Spearman-Brown reliability coefficient of .90, Guttman split-half reliability of .89 and Cronbach's coefficient alpha of .96.

Construct Validity

Construct validity was established using two methods. First, the MARSA scores were shown to be statistically significantly ($p < .001$) correlated with grades in math courses of the sample, so that high anxiety was accompanied by low grades. Second, higher enrollment in math and science courses was shown to be related to lower MARSA scores, and higher MARSA scores were associated with avoidance of expressed career intentions that involve higher levels of math and science.

Performance in Mathematics

Performance in math will be measured by each student's self-reported midterm mark in grade 10 math. Grades are coded so that higher scores meant higher grades. Scores range from 2 for less than 50% (failure); 3 for marks at or above 50% and less than 55%; to 10 for marks at or above 95%. All students are assessed by their grade 10 math teacher.

Confidence in Learning Mathematics Subscale of the Mathematics Attitude Scale (CMAS)

The Confidence in Learning Mathematics subscale of the Mathematics Attitude Scale(CMAS; see appendix B), developed by Fennema and Sherman (1976), was used to assess math self-concept. The CMAS is a 12-item 5 point Likert-type scale (responses range from 1=strongly disagree to 5=strongly agree). Low scores on the subscale reflect low math self-concept.

The CMAS is designed to assess students' confidence in their ability to learn math, more specifically, it assesses how sure a person is of being able to learn new topics in math, perform well in math courses, and do well on math tests. Typical questions include "I am sure I could do advanced work in mathematics," "I can get good grades in math," and "Most subjects I can handle OK, but I have a knack for flubbing math."

Content Validity

Content validity was established through the procedures of refining the number of items per subscale. For each subscale, only those items were included that differentiated math and non-math students and those that "yielded scores consistent with the theoretical construct of the subscale" (Fennema & Sherman, 1976, p. 6).

Reliability

The CMAS was found to have a spit-half reliability coefficient of .93 (n=367). Test-retest stability was not provided.

Data Collection

In the spring of 2000 the MARSA, the CMAS, and the performance and gender scales were administered to the grade 10 sample population (n=320). The questionnaires were administered to groups of students during school hours, and took approximately 25 minutes to complete. All grade students approached to

Data Analysis

The statistical procedures used in the study are grouped according to the six research questions, p. 2:

1. a) Do higher levels of math anxiety accompany lower levels of performance among grade 10 advanced students in Northwestern Ontario?

   b) Does this relationship exist for males and females?

To answer the first research question, Pearson correlation coefficients for the MARSA by Performance were calculated for the total sample. Correlation coefficients were also calculated separately for males and females.

2. a) Are higher levels of math self-concept linked to higher levels of performance among grade 10 advanced students in Northwestern Ontario?

   b) Does this relationship exist for males and females?

To answer the second research question, Pearson correlation coefficients for the CMAS by Performance were calculated for the total sample. Correlation coefficients were also calculated separately for males, and females.

3. a) Are higher levels of math anxiety accompanied by lower levels of math self-concept among grade 10 advanced students in Northwestern Ontario?
   b) Does this relationship exist for males and females?

To answer the third research question, Pearson correlation coefficients for the MARSA by CMAS were calculated for the total sample. Correlation coefficients were also calculated separately for males and females within each group.

4. Is there a difference in the strength of the math anxiety/performance relationship, and the math self-concept/performance relationship?

To answer the fourth research question the relative strength of the math anxiety/performance, and math self-concept/performance relationship the absolute value of the correlations between the MARSA and Performance, and the CMAS and Performance were considered so that the strength of the correlations, and not the direction could be compared. To determine whether the math self-concept and performance relationships were statistically significantly stronger than the relationships between math anxiety and performance, t-tests were performed. The t-test formula used to determine the significance of the difference between correlations for N-3 degrees of freedom is as follows:

$$t = \frac{r_{xy} - r_{vy}\sqrt{(n-3)(1+r_{xv})}}{\sqrt{2(1-r_{xy}^2-r_{vy}^2-r_{xv}^2+2r_{xy}r_{vy}r_{xv})}}$$

Formula 1 t-test for the significance of the difference between correlations, where x, y and v are variables and r_{xy} is the correlation between variables x and y (from Cohen, 1975, p. 53)

5. Is there is a gender difference in the strength of the math anxiety/performance relationship, or the math self-concept/performance relationship?

To determine if the gender differences in the strength of the math anxiety/performance, or math self-concept/performance relationship were statistically significant, Fisher's z' transformation and comparison between independent correlations (Cohen, 1975) were calculated. Z values where calculated for pairs of correlations—correlations of males and females for the relationship—from which the corresponding p values where obtained. The formula for the z value is as follows:

$$z = \frac{z_1^{'} - z_2^{'}}{\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}}}, z' = .5 \ln \frac{1 + r}{1 - r}$$

Formula 2 Fisher's z' transformation and Comparison of Independent Correlations (from Cohen, 1975, p.51)

6. Is there is a gender gap in math anxiety, or math self-concept?

To answer the sixth research question, t-tests where performed by gender on the means of the MARSA, and the CMAS for the total sample.

Limitations of the Study

In the current study, students' performance in math was measured by their self-reported midterm mark in math; students were required to indicate the category in which their mark fell (e.g., 65% to 69%). This method of measuring performance presents several possible problems. First, students may not have reported their mark accurately. However, the risk of false reporting seems small since students did not write their names on the questionnaires, hence a student's mark could not be identified by name from the questionnaire. Also, students were asked their midterm mark on the second page of the questionnaire so that other students would be less likely to see a student's mark.

The reliability of the performance scale may be problematic. Different teachers, schools, or school boards may have different standards; a mark that a student receives from one teacher could be different from the mark another math teacher assigns that same student. This problem is reduced since each student in the study was following the same curriculum, at the same level, and is required to meet the same objectives. A standardized achievement test was not used in the current study because, under school board regulations, students could not be identified in any way in the study: Students could not write their names, or identify themselves on any questionnaire. Hence, all instruments had to be administered to a given student at the same time so that the researcher could identify the different questionnaires filled out by that student. Administering a valid and accurate achievement test together with the other scales used in the study would have been too time-consuming.

The design of the current study enabled gender differences in math anxiety and math self-concept to be identified. It could not, however, clearly illuminate reasons, or causes of the gender differences. Such knowledge would be of great value in ending gender inequity in math education.

The sample used in the current study was not truly a random sample of grade 10 advanced students in Northwestern Ontario. Schools within each school board were chosen randomly, and all grade 10 advanced math classes were involved within each school. However, the two school boards were not chosen randomly, but were selected due to their willingness to participate. Hence, the results of the current study cannot truly be generalized to all grade 10 advanced students in Northwestern Ontario.

CHAPTER IV

RESULTS

The results are organized according to the six research questions.

1. a) Do higher levels of math anxiety accompany lower levels of performance among grade 10 advanced students in Northwestern Ontario?

   b) Does this relationship exist for males and females?

Pearson correlation coefficients for the MARSA by Performance were calculated for the total sample. Correlation coefficients were also calculated separately for males, and females (see Table 1, p. 64).

Low to moderate correlation coefficients, which were statistically significant, were found for the MARSA by Performance for the total sample, and separately for males and females. The correlation was -.344 ($p = .01$) for the total sample, -.366 ($p = .01$) for males, and -.329 ($p = .01$) for females. The results indicate that higher levels of math anxiety were accompanied by lower levels of performance and that the relationship holds for males and females.

2. a) Are higher levels of math self-concept linked to higher levels of performance among grade 10 advanced students in Northwestern Ontario?

   b) Does this relationship exist for males and females?

Pearson correlation coefficients for the CMAS by Performance were calculated for the total sample. Correlation coefficients were also calculated separately for males, and females (see Table 1, p. 64).

Statistically significant, moderate to high correlation coefficients of the CMAS by Performance were found for the total sample, and for each gender. A correlation of .641 (p= .01) was found for the total sample. For males the correlation was .689 (p= .01), and for females it was .632 (p= .01). Hence, higher levels of math self-concept were accompanied by higher levels of performance in the total sample. This relationship held for males and females.

3. a) Are higher levels of math anxiety accompanied by lower levels of math self-concept among grade 10 advanced students in Northwestern Ontario?

   b) Does this relationship exist for males and females?

Pearson correlation coefficients, which were statistically significant, for the MARSA by CMAS were calculated for the total sample. Correlation coefficients were also calculated separately for males, and females (see Table 1 p. 64).

Moderate to high correlation coefficients of the MARSA by CMAS were found for the total sample, and for males and females. The correlation was -.536 (p= .01) for the total sample, -.464 (p= .01) for males, and -.568 (p= .01) for females. The results indicate that higher levels of math anxiety are accompanied by lower levels of math self-concept in the total sample, and the relationship holds for males and females.

Table 1

Pearson Correlation Coefficients for Instruments

Group	MARSA/Performance	CMAS/Performance	MARSA/CMAS
Total Sample	-.344* n=316	.641* n=319	-.536* n=316
Females	-.329* n=174	.632* n=174	-.568* n=176
Males	-.366* n=141	.689* n=144	-.464* n=141

* p= .01

4. Is there a difference in the strength of the math anxiety/performance relationship, and the math self-concept/performance relationship?

The absolute value of the MARSA/Performance, and the CMAS/Performance correlations were considered so that the strength of the correlations, and not the direction could be compared.

In the total sample, and for both genders, the math self-concept/performance relationship was stronger than the math anxiety/performance relationship (see Table 2, p. 66). The absolute value for the total sample of the correlation for math self-concept/ performance was .641 (p= .01), and for math anxiety/performance it was .344 (p= .01). For males, the absolute value of the correlation for math self-concept/performance was .689 (p= .01), and for math anxiety/performance it was .366 (p= .01). For females the absolute value of the correlation for math self-concept/performance was .632 (p= .01), and for math anxiety/performance it was .329 (p= .01).

To determine whether the math self-concept/performance relationships were statistically significantly stronger than the math anxiety/performance relationships, t-tests were performed. The t-test formula used to determine the significance of the difference between correlations for N-3 degrees of freedom is as follows:

$$t = \frac{r_{xy} - r_{vy}\sqrt{(n-3)(1+r_{xv})}}{\sqrt{2(1-r_{xy}^2 - r_{vy}^2 - r_{xv}^2 + 2\,r_{xy}r_{vy}r_{xv})}}$$

Formula 1 t-test for the significance of the difference between correlations, where x, y and v are variables and r_{xy} is the correlation between variables x and y (from Cohen, 1975, p. 53)

The t values for math anxiety/performance, and math self-concept/performance relationships were larger than the critical t values (two-tailed, for =.01) in the total sample, and for both genders. Since the t values were greater than the critical values (=.01), the differences in the correlations were statistically significant at the 1% level for each group. This result indicates that the math self-concept/performance relationship was stronger than the math anxiety/performance relationship for the total sample, and for both genders. Math self-concept was more closely linked to performance than was math anxiety. This characteristic held for males and females.

Table 2

Significance of Difference between Correlations
Math Self-Concept/Performance and Math Anxiety/Performance

Group	MARSA/Performance Correlation (Absolute Value)	CMAS/Performance Correlation (Absolute Value)	Difference	t
Total Sample	.641 n= 316	.344 n=316	.297	7.11*
Females	.632 n=174	.329 n=174	.303	5.11*
Males	.689 n=141	.366 n=144	.323	5.59*

* p= .01

5. Is there is a gender difference in the strength of the math anxiety/performance relationship, or the math self-concept/performance relationship?

Math Anxiety/Performance

The correlation for the math anxiety/performance relationship was stronger for males than females: The correlation was -.366 (p= .01) for males and -.329 (p= .01) for females. However, the gender difference in the strength of the relationship was not statistically significant. Hence, the strength of math anxiety/performance relationship was similar for males and females in this study.

To determine if the gender difference in the strength of the math anxiety/performance relationship, and the math self-concept/performance relationship was statistically significant, Fisher's z' transformation and comparison between independent correlations (Cohen, 1975) were calculated. Z values where calculated for pairs of correlations— correlations of males and females for the relationship—from which the corresponding p values where obtained. The formula for the z value is as follows:

$$z = \frac{z_1' - z_2'}{\sqrt{\frac{1}{N_1 - 3} + \frac{1}{N_2 - 3}}}, \quad z' = .5 \ln \frac{1+r}{1-r}$$

Formula 2 Fisher's z' transformation and Comparison of Independent Correlations (from Cohen, 1975, p.51)

The p value (two-tailed) for the corresponding z value for the gender difference in the relationship was greater than .05. Hence, the gender difference in the strength of the relationship was not significant for any group (The results are summarized in Table 3, p. 68).

Math Self-Concept/Performance

The math self-concept/performance correlation was higher for males than females: The correlation was .689 (p= .01) for males and .632 (p= .01) for females. However, the gender difference was not statistically significant. In each group, the p values (two-tailed) for the corresponding z values were greater than .05, and hence the gender differences in the relationships were not statistically significant (see Table 3 p. 68).

Table 3

Significance of Gender Differences between Correlations
Math Anxiety/Performance and Math Self-Concept/Performance

Relationship	Female	Male	Difference	z	p value (Two-tailed)
CMAS/Performance Correlation	.632 n=174	.689 n=144	.057	.896	.6318
MARSA/Performance Correlation	-.366 n=174	-.329 n=141	0.037	.400	.6892

6. Is there is a gender gap in math anxiety, or math self-concept?

T-tests were performed by gender on the means of the MARSA (see Table 4, p. 69), and the CMAS (see Table 5, p. 71).

Math Anxiety

Females in the total population had a mean MARSA score of 201.18, and males a mean score of 183.33. The mean difference was found to be statistically significant (t= -2.490, p= .013), indicating that females in this study had more math anxiety than males. The results are illustrated in a box plots in Figure 2 (p. 70). The box plots illustrate the mean, range, and the interquartiles of MARSA scores for males and females.

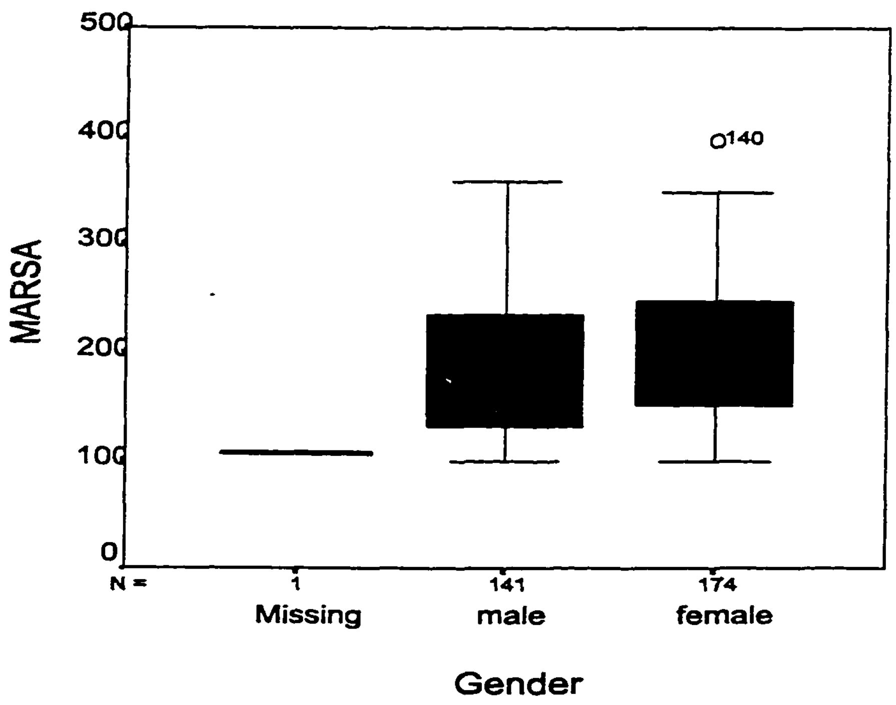
Table 4

Gender Difference in Math Anxiety

MARSA	n	Mean	Mean Difference	t	Standard Deviation
Females	141	201.18	17.85	-2.490*	64.14
Male	174	183.33			62.18

* p= .013 (2-tailed)

Figure 2 Box Plot of MARSA by Gender



Math Self-Concept

Males had a mean CMAS score of 46.88, and females a mean score of 42.79. A t-test was performed on the CMAS by gender which indicated that the gender difference was statistically significant (t= 3.434, p= .001). The results imply that males in this study had higher math self-concept than females. The results are illustrated in a box plot in Figure 3 (p. 71). The box plots illustrate the mean, range, and the interquartiles of CMAS scores.

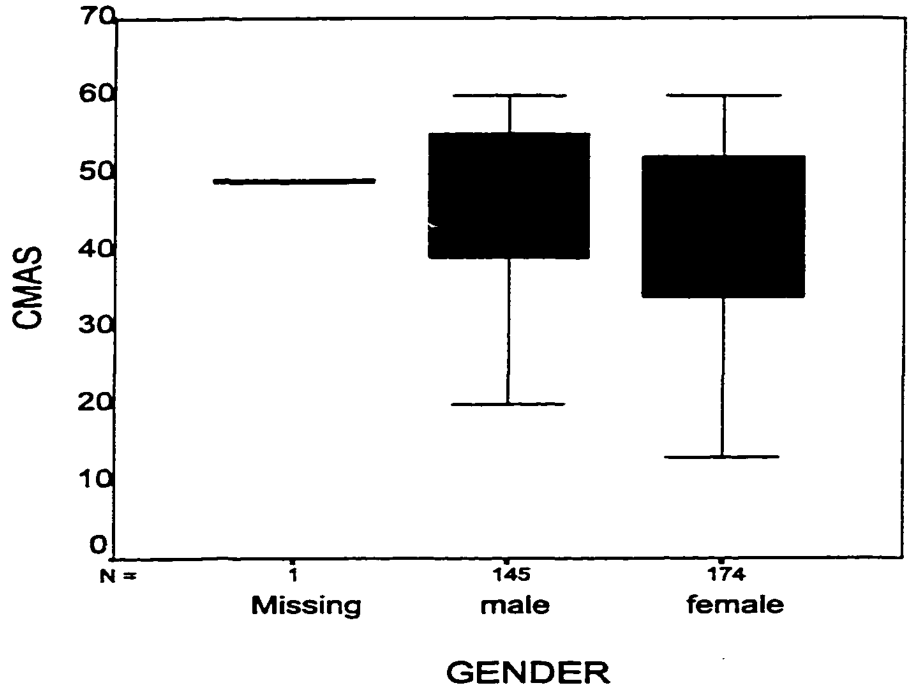
Table 5

Gender Difference in Math Self-Concept

CMAS	n	Mean	Mean Difference	t	Standard Deviation
Female	174	42.88	4.10	3.434*	11.09
Male	145	46.88			9.99

* p= .001 (2-tailed)

Figure 3 Box Plot of CMAS by Gender



CHAPTER V

DISCUSSION

Math Anxiety and Performance

Research over the past thirty years has consistently found that higher levels of math anxiety are accompanied by lower levels of performance in math. This relationship has been established with students in elementary school (Satake & Amato, 1995), middle school (Tocci & Engelhard, 1991), high school (Suinn & Edwards, 1982; Thondike-Christ, 1991), and university (Adams & Holcomb, 1986; Cooper & Robinson, 1991), for both males and females (Hembree, 1990; Ma, 1999), using various measures of math anxiety, and performance (Wigfield, Meece, & Eccles, 1990; Ma, 1999).

Consistent with the literature, the current study found that higher levels of math anxiety were linked to lower levels of performance, and that this relationship held for both genders. Low to moderate correlations for the math anxiety/performance relationship were found for the total sample (-.344, p= .01), females (-329, p= .01), and males (-.366, p= .01).

The research in the literature review tended to find no gender difference in the strength of the math anxiety/performance relationship, although few studies have examined this aspect of the relationship. Hembree's (1990) meta-analysis primarily of studies with university students, found no gender difference among university students, but reported that the relationship was stronger among male than female preuniversity students. Ma (1999) found no gender difference in the strength of the relationship among studies involving preuniversity students. The current study found no gender difference in the math anxiety/performance relationship. Hence, the results indicate that math anxiety functions in a similar way for males and females with respect to performance for the sample of advanced grade 10 students from Northwestern Ontario.

Math Anxiety, Math Self-Concept and Performance

Studies have typically found that higher levels of math anxiety are accompanied by lower levels of math self-concept among university students (Rounds & Hendel, 1980b; Hackett & Betz, 1989; and Dwinell & Higbee, 1991), and preuniversity students (Thorndike-Christ, 1991; and Casey, Nuttall, Pezaris, 1997); This relationship held for both genders.

In agreement with the literature, the current study found a moderate to high negative correlation for the math anxiety/math self concept relationship in the total sample (-.536, p=.01), for females (-.568, p= .01), and for males (-.464, p= .01). The results suggest that higher levels of math anxiety are linked to lower levels of math self-concept, and indicate that the relationship held for both males and females.

Research has consistently found that higher levels of math self-concept are linked to lower performance. This characteristic has been found for both genders (Tartre & Fennema, 1995), among preuniversity (Fennema & Sherman, 1978; Thorndike-Christ, 1991; Tartre & Fennema, 1995), and university students (Rounds & Hendel, 1980b; Dwinell & Higbee, 1991). Concordant with the literature, the current study found that higher levels of math self-concept were associated with higher levels of performance.

Moderate correlations were found for the math self-concept/performance relationship in the total sample (.641, p=.01), for females (.632, p= .01), and for males (.689, p= .01).

In the current study, the strength of the correlations for the math self-concept/performance relationship did not differ by gender. The results indicate that math self-concept functions in a similar fashion with respect to performance for both males and females, supporting the few studies examining gender differences in the strength of the relationship (Sherman, 1979; Dwindell & Hibgee, 1991; Tartre & Fennema, 1995).

Rounds and Hendel (1980b), Gourgey (1982), and Pajares and Miller (1994) found no difference in the strength of the math self-concept/performance, and the math anxiety/performance relationship among university students, while Hembree's (1990) meta-analysis reported that math self-concept was more strongly linked to performance than was math anxiety. The inconsistency of studies involving university students was not present in studies involving preuniversity students. Thorndike-Christ (1991), and Casey et al. (1997) reported that math self-concept was more strongly linked to performance than was math anxiety among samples of preuniversity students. Differences in the strength of the relationship were not, however, examined among males and females separately. In agreement with the literature involving preunivesity students, the current study found that the correlation for math self-concept/performance to be significantly stronger than that for math anxiety/performance in the total sample. This characteristic was also found separately for males and females. Hence, the results of the current study suggest that math self-concept was more closely linked to performance than was math anxiety, and indicate that this characteristic held for males and females.

Gender Differences in Math Anxiety and Math Self-Concept

Math Anxiety

Research involving university and preuniversity students investigating gender differences in math anxiety has reported varying findings. Studies often report that females experience more math anxiety than males (Llabre & Suarez, 1985; Wigfield & Meece, 1988; Randhawa, 1994; Satake & Amato, 1995), while other studies report no significant difference (Resnick, Viehe, & Sanford, 1982; Wahl, 1985; Gressard & Loyd, 1987). Randhawa (1994) found that females experience more math anxiety than males in a sample of grade 12 students from Saskatchewan (n=191), but few other studies appear to have investigated gender differences among students form Canada, let alone Northwestern Ontario. In the current study, the mean MARSA score for females (201.18) was found to be significantly higher (t= -2.490, p=.013) than the mean for males (183.33). Females experienced more math anxiety than males.

Math Self-Concept

Studies investigating gender differences in math self-concept have not been consistent. It appears that there may be a shift in the results from studies among preuniversity students to studies involving university students. Among preuniversity students, studies have either reported no gender gap in math self-concept (Felson & Trudeau, 1991; Tartre & Fennema, 1995), or that males have higher math self-concept than females (Fennema & Sherman, 1977a; Eccles, 1983; Thorndike-Christ, 1991).

Studies involving university students typically report no gender gap in math self-concept (Dwindell & Higbee, 1991; Pajares & Miller, 1994). However, Rogerson (1978) found that females had higher math self-concept than males in a sample of university students. It may be that females with low self-concept drop math by the time they reach university. In the current study, the mean CMAS score was 42.88 for females and 46.88 for males, and the difference was statistically significant ($t = 3.434$, $p = .001$). Hence, males had higher math self-concept than females.

Summary and Implications

Many of the findings of the current study support the results of previous research in a sample of grade 10 advanced students from Northwestern Ontario. Higher levels of math anxiety were accompanied by lower levels of performance and lower levels of math self-concept. Higher math self-concept was linked to higher performance. These relationships were found to hold for both males and females. The results reaffirm the importance of math anxiety, and math self-concept due to their relationship to performance in math. The literature has shown that these attitudinal variables also affect students future enrollment intentions in advanced math courses (Wigfeild & Meece, 1988). Clearly there is a need for teachers and administrators to address math anxiety, and math self-concept to best facilitate students' performance, and enrollment intentions in math.

The correlations for math anxiety/performance, and math self-concept /performance were similar in magnitude for both genders. Thus, math anxiety and math self-concept were found to function similarly for both males and females with respect to performance.

Math self-concept was found to be more closely linked to performance than was math anxiety. This characteristic held for males and females separately. Although math anxiety has received much more attention than math self-concept in the literature, it appears that math self-concept may be more important to math education due to its close link to performance.

Females where found to have lower math self-concept and higher math anxiety than males. To ensure gender equity in math education, programs should be developed and implemented in Northwestern Ontario to bolster females' math self-concept, and prevent and treat math anxiety. Such programs will ultimately also help males. To create effective programs, contributing factors to the gender gap must be identified. Fennema and Leder (1990), and the AAUW (1991) reported that student teacher classroom interactions are different for males and females such that males get more attention and instructional time. Parsons et al. (1982), in a study involving 17 grade 5, 6, 7, and 9 math classrooms, found that students with higher math self-concept tended to have a higher proportion of interactions yielding praise, and higher incidences of work criticism after a student-initiated question, and less public feedback after a public error than a student with lower math self-concept. It is plausible that differential classroom interactions contribute to the gender gap in math self-concept, but more research must be done in this area.

The cause of the gender gap in math anxiety is uncertain. Richardson and Woolfolk (1980) suggested that math anxiety is not related to gender, but rather is due to one's preparation in math, regardless of gender. These researchers asserted that if females experience more math anxiety than males, than it is a result of their weak math backgrounds compared to males. However, research does not support this assertion (Rescick, Viehe, & Sanford, 1982; Llabre & Suarez, 1985). Some researchers have suggested that a response bias may account for the gender gap (Meece et al., 1982; Hunsley & Flessati, 1988), while other researchers claim that females' perception of math as a male domain may lead females to experience higher levels of math anxiety than males (Tobias, 1976b; Fennema & Sherman, 1977b). However, neither purported cause of the gender gap in math anxiety is supported by research (Rounds & Hendel, 1980b; Sherman, 1980; Flessati, 1990).

Directions for Future Research

Future research should investigate the relationship between teaching methods and levels of math anxiety and math self-concept, and whether instructional methods affect males and females in similar ways. In an opinion piece, Greenwood (1984) argued that "the major source of math anxiety lies is the impersonal, nongrowth, nonrational methodologies that are characterized by the explain-practice-memorize (teaching) paradigm" (p. 663). Future research could compare the effects of inquiry, problem-solving-based instruction with the explain-practice-memorize paradigm on math anxiety, and math self-concept, in addition to other attitudinal variables such as students' enjoyment of math.

The American Association of University Women (1991) argued that classroom interactions between teachers and students are biased in favor of male students. Future research should explore gender differences in math classroom interactions, and examine how these differences affect attitudinal variables among males and females.

The relationship between students' socioeconomic status (SES) and their attitudes toward math has not been studied extensively, possibly because of the sensitivity of the information required to determine SES. More research in this area would certainly contribute to making math education equitable.

In Ontario there are several educational streams: Enriched, advanced, basic, and general (up to September 2000); and academic, applied (grades 9, 10), university preparation, college preparation, and workplace preparation (grades 11, 12) (September, 2000). It would be valuable to investigate the differences in students' attitudes toward math in the different educational streams. It would also be useful to examine differences in teachers' attitudes towards, and interactions with students in the various streams and how these affect students' attitudes toward math.

In the literature it appears that isolating a gender gap in math anxiety is dependent on the sample studied. It is vital to achieving gender equity in math education to determine why in some samples, females experience more math anxiety than males while in other samples there is no gender difference. Some possible areas of exploration have been noted above: Differential classroom interactions between males and females, attitudinal variables held by students, parents, and teacher, and SES.

Both the current study and past research has illustrated that math anxiety, and math self-concept are important due to their relationship with performance for both males and females. It is time that something is done to address high levels of math anxiety, and low math self-concept, particularly in females, through programmatic and pedagogical changes.

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Appendix A

NATURE OF THE STUDY

Dear Student:

I am a graduate student in Curriculum Studies at the Faculty of Education at Lakehead University. I am conducting research on students' attitudes toward mathematics and how these attitudes affect the grades you receive in mathematics under the supervision of Dr. Juanita Epp. I would like to include you in the study.

The purpose of the study is to learn more about the relationship among students' attitudes toward mathematics and the grades they receive in mathematics. Specifically, the attitudes that I am investigating are anxiety toward mathematics and confidence in learning mathematics. I am also interested in determining if either gender experiences more anxiety toward mathematics, or has higher confidence in learning mathematics.

Participation in the study will involve filling out three questionnaires about (a) anxiety in math, (b) confidence in learning math, and (c) the mark in math that you received on the midterm report card. Your gender will be asked on one of the questionnaires. The questionnaires will take approximately 25 to fill out.

This study has been approved by the Lakehead University Senate Research Ethics Board, (Board of Education name) Superintendent of Research, and by Mr(s). (Principals' name) at (School name).

No person other than myself will have access to the information you provide in filling out the questionnaires. Your responses will not be identified by name and I will not use any information from the school's records. When the study is completed, the information will be securely stored at Lakehead University for seven years. A report of the findings will be made available to interested parents and students at Lakehead University's Faculty of Education Library upon completion.

Participation in this research is completely voluntary. I will seek your consent. If for any reason you do not want to complete the questionnaires, you will not be made to participate. Furthermore, you can withdraw from the study anytime without penalty whatsoever.

If you would like to receive more information about the study, please contact me at 343-8837. I would sincerely appreciate your cooperation.

Thank you,

Andrew Douglas
Masters' Candidate
Faculty of Education, Lakehead University

Appendix B

Confidence in Learning Mathematics

The following are a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed.

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

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
11. Math has been my worst subject.	____	____	____	____	____
12. I can get good grades in math.	____	____	____	____	____

Appendix C

INFORMATION ON PERFORMANCE IN MATHEMATICS AND GENDER

Please answer the following questions on your mark in mathematics on the midterm, and your gender (MALE / FEMALE). Circle the response that pertains to you.

PERFORMANCE IN MATHEMATICS

1. Check the box below which best represent the mark that you received on the midterm in mathematics (If you do not know the category in which your mark falls, leave the question blank).

95% to 100	65% to 69%
90% to 94%	60% to 64%
85% to 89%	55% to 59%
80% to 84%	50% to 54%
75% to 79%	below 50%
70% to 74%	

GENDER

2. I am **MALE / FEMALE.** (Circle one)

Appendix D

Mathematics Anxiety Rating Scale for Adolescents (MARSA)

Total Score ____________

MATHEMATICS ANXIETY RATING SCALE (MARS-A)

The items in the questionnaire refer to things and experiences that may cause tension or apprehension. For each item, place a check (✓) in the circle under the column that describes how much you would be made anxious by it. Work quickly, but be sure to think about each item.

How anxious . . .	Not at all	A little	A fair amount	Much	Very much
1. Deciding how much change you should get back from buying several items.	O	O	O	O	O
2. Having someone watch you as you add up a column of numbers.	O	O	O	O	O
3. Having someone watch you as you divide a five digit number by a two digit number.	O	O	O	O	O
4. Being asked to add up 976 + 777 in your head.	O	O	O	O	O
5. Adding up 976 + 777 on paper.	O	O	O	O	O
6. Figuring out a simple percentage, like the sales tax on something you buy.	O	O	O	O	O
7. Figuring out how much you will get paid for 6½ hours of work if you get paid $3.75 an hour.	O	O	O	O	O
8. Listening to a person explain how your share of expenses on a trip was figured out (including meals, transportation, housing, etc.).	O	O	O	O	O
9. Counting a pile of change.	O	O	O	O	O
10. Adding up a bill for a meal when you think you have been over-charged.	O	O	O	O	O

How anxious . . .	Not at all	A little	A fair amount	Much	Very much
11. Telling the cashier that you think the bill for the meal was wrong and watching the cashier add up the bill again.	O	O	O	O	O
12. Being asked to make change.	O	O	O	O	O
13. Adding up the dues received and the expenses for a club you belong to.	O	O	O	O	O
14. Reading a formula in a science class.	O	O	O	O	O
15. Doing a word problem in algebra.	O	O	O	O	O
16. Solving a problem such as: If $x = 11$, and $y = 3$, then the result of x/y is equal to ________?	O	O	O	O	O
17. Solving the problem such as: If $x = 12$, and $y = 4$, then the ratio of x to y is equal to ________?	O	O	O	O	O
18. Figuring out your grade average for last term.	O	O	O	O	O
19. Reading an article on the basketball team, showing what percentage of free throws each player made, the percentage of field goals made, the total number attempted, etc.	O	O	O	O	O
20. Reading a novel with many dates in it.	O	O	O	O	O
21. Being asked to remember the telephone numbers of three people you met.	O	O	O	O	O
22. Being asked to guess at the number of people at a large gathering you are attending.	O	O	O	O	O
23. Receiving a math textbook.	O	O	O	O	O

	How anxious ...	Not at all	A little	A fair amount	Much	Very much
24.	Watching a teacher work an algebra problem on the blackboard.	O	O	O	O	O
25.	Figuring out whether you have enough change to pay for the gum and magazine you want to buy, plus the sales tax.	O	O	O	O	O
26.	Signing up for a math course.	O	O	O	O	O
27.	Listening to another student explain a math formula.	O	O	O	O	O
28.	Walking into a math class.	O	O	O	O	O
29.	Having to figure the miles per gallon of gas for a car.	O	O	O	O	O
30.	Watching someone work with a calculator.	O	O	O	O	O
31.	Looking through the pages of a math text.	O	O	O	O	O
32.	Signing up for a course in Algebra.	O	O	O	O	O
33.	Being called on to put a problem on the board when you are not sure your answer is right.	O	O	O	O	O
34.	Studying for a math test.	O	O	O	O	O
35.	Starting to read a new chapter in a math book.	O	O	O	O	O
36.	Walking to class and thinking about a math course.	O	O	O	O	O
37.	Meeting your math teacher while walking in the hall.	O	O	O	O	O
38.	Reading the word "Statistics".	O	O	O	O	O

	How anxious . . .	Not at all	A little	A fair amount	Much	Very much
39.	Sitting in a math class and waiting for the teacher to begin.	O	O	O	O	O
40.	Solving a square root problem.	O	O	O	O	O
41.	Signing up for a course in Geometry.	O	O	O	O	O
42.	Collecting money for admission tickets to a show or a game at the door.	O	O	O	O	O
43.	Taking the math section of a standardized test, like an achievement test.	O	O	O	O	O
44.	Measuring how much border to leave and how to place five pictures on a bulletin board.	O	O	O	O	O
45.	Raising your hand in a math class to ask a question about something you do not understand.	O	O	O	O	O
46.	Reading and interpreting graphs or charts.	O	O	O	O	O
47.	Reading a cash register receipt after you buy something.	O	O	O	O	O
48.	Figuring the sales tax for something that costs more than $1.00.	O	O	O	O	O
49.	Having to know how to balance a checkbook by adding up every amount that was spent and subtracting it from the amount you started with.	O	O	O	O	O
50.	Figuring how you would make more money: by taking a job that has a lower salary, but includes, room, meals, and travel; or a job that has a higher salary, but no other benefits.	O	O	O	O	O
51.	Having someone explain bank interest rates while describing savings accounts.	O	O	O	O	O

How anxious . . .	Not at all	A little	A fair amount	Much	Very much
52. Hearing a lecture in a social studies class where the teacher is commenting on some figures, like the percentage of each socio-economic group who voted Republican.	O	O	O	O	O
53. Taking an examination (quiz) in a math course.	O	O	O	O	O
54. Taking an examination (final) in a math course.	O	O	O	O	O
55. Hearing two of your friends talking about the best way to figure out the actual cost of a product.	O	O	O	O	O
56. Having someone ask you to recheck the numbers in a simple calculation, such as division or addition.	O	O	O	O	O
57. Being asked by a friend to answer the question: "How long will it take to get to the state capital if I drive at 30 miles per hour?"	O	O	O	O	O
58. Studying for a driver's license test and memorizing the numbers involved, such as the distances it takes to stop a car going at different speeds.	O	O	O	O	O
59. Hearing friends quote the odds on a game as they make bets.	O	O	O	O	O
60. Playing cards where numbers are involved, like poker or blackjack.	O	O	O	O	O
61. Having a friend try to teach you how to do a math problem and finding that you cannot understand what is being said.	O	O	O	O	O
62. Making a schedule for your daily routine, setting aside times for classes, study time, meals, recreation, etc.	O	O	O	O	O

How anxious . . .	Not at all	A little	A fair amount	Much	Very much
63. Learning the part of a game dealing with scoring and remembering numbers.	O	O	O	O	O
64. Deciding which courses to take in order to come out with enough credit hours for promotion or graduation.	O	O	O	O	O
65. Working a math problem that is important in your life, like figuring out how much you can spend on recreational activities such as movies after buying other things you need.	O	O	O	O	O
66. Working on a math problem which seems less important in your life, such as "If x = outstanding bills, and y = total income, calculate how much is left for recreational purposes."	O	O	O	O	O
67. Being given a set of addition problems to solve on paper.	O	O	O	O	O
68. Being given a set of subtraction problems to solve on paper.	O	O	O	O	O
69. Being given a set of multiplication problems to solve on paper.	O	O	O	O	O
70. Being given a set of division problems to solve on paper.	O	O	O	O	O
71. Picking up your math textbook to begin working on a homework assignment.	O	O	O	O	O
72. Being given a homework assignment of many difficult math problems, which is due the next time the class meets.	O	O	O	O	O
73. Thinking about an upcoming math test one week before.	O	O	O	O	O

How anxious . . .	Not at all	A little	A fair amount	Much	Very much
74. Thinking about an upcoming math test one day before.	O	O	O	O	O
75. Thinking about an upcoming math test one hour before.	O	O	O	O	O
76. Thinking about an upcoming math test five minutes before.	O	O	O	O	O
77. Checking the time and figuring out whether or not you can stop in two more stores and still meet a friend at the exact time you said you would.	O	O	O	O	O
78. Waiting to get a math test returned on which you expected to do well.	O	O	O	O	O
79. Waiting to get a math test returned on which you expected to do poorly.	O	O	O	O	O
80. Asking your math teacher after class about something you did not understand.	O	O	O	O	O
81. Realizing that you have to take a certain number of math classes to meet the requirements for graduation.	O	O	O	O	O
82. Picking up a math textbook to begin a difficult reading assignment.	O	O	O	O	O
83. Being called on to answer a question in a math class on a topic you have spent some time studying.	O	O	O	O	O
84. Not knowing the formula needed to solve a particular problem.	O	O	O	O	O
85. Receiving your final math grade on your report card.	O	O	O	O	O
86. Figuring out how much material you will need to do a project so that you will waste as little as possible.	O	O	O	O	O

How anxious . . .	Not at all	A little	A fair amount	Much	Very much
87. Being responsible for collecting the dues for a club and keeping track of the amount received.	O	O	O	O	O
88. Opening a math or statistics book and seeing a page full of problems.	O	O	O	O	O
89. Watching someone use a graph to explain something.	O	O	O	O	O
90. Listening to a lecture in a math class.	O	O	O	O	O
91. Being given a "pop" quiz in a math class.	O	O	O	O	O
92. Seeing a computer printout.	O	O	O	O	O
93. Having to use the tables in the back of a math book.	O	O	O	O	O
94. Comparing the prices of two brands of soft drinks that are different sizes and deciding which is cheaper.	O	O	O	O	O
95. Deciding how much of a tip to leave in a restaurant after a meal.	O	O	O	O	O
96. Being asked to explain how you arrived at a particular answer for a problem.	O	O	O	O	O
97. Adding up the results of a vote, such as for class or student body representative.	O	O	O	O	O
98. Acting as secretary, keeping track of the number of people signing up for an event.	O	O	O	O	O