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ABSTRACT

This paper presents a meta-analysis study that addresses gender differences in student attitudes toward mathematics for the years 1970 to 1995. A body of 96 primary studies were used including 30,490 students (15,877 female and 14,613 males), 69 journal articles, and 27 ERIC documents in the analysis. The major conclusion of this study is that gender differences in student attitudes toward mathematics do exist but are small. Males are favored, indicating more positive attitudes toward mathematics. (Contains 60 references and 16 tables.) (ASK)

A Meta-Analysis of Gender Differences in Student Attitudes toward Mathematics

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Background

Interest in gender differences in cognitive abilities, has a long history (Stroud & Lindquist, 1942; Anastasi, 1958; Tyler, 1965) which intensified with the extensive review of literature of gender differences in academic achievement by Maccoby and Jacklin (1974). Three major conclusions emerged from this review: (1) males tended to do better than females on tests of mathematical ability from age 13; (2) males tended to outperform females in tests of visual-spatial ability; and (3) females performed better on tests of verbal ability than males. A decade later, Stage, Kreinberg, Eccles, and Becker (1985) reviewed the literature on gender and mathematics performance up to 1985 and reported that high school boys performed slightly better than high school girls on tests of mathematical reasoning (primarily solving word problems); but girls occasionally outperformed boys on tests of computational skills. Further, in a meta-analysis of gender differences in mathematical performances, Hyde & Fennema (1990), found that gender differences favored females in computation in elementary and middle schools but favored males in problem-solving in high school.

A study of 1324 school children in grades 2 through 12 did not find any statistically significant gender differences in the reported enjoyment of mathematics but when mathematics became optional in high school and college, very few females chose to continue studying mathematics (Ernest, 1976). It was also found (Grandy, 1987) that males and females of elementary age reported equal interest in careers in mathematics and science, yet at the end of high school about 40% of college-bound males as compared with 20% of college-bound females reported such interests. It was further reported that in 1975-76 "for all doctorate-granting mathematics departments in the United States, women comprised only 4.8% of the regular ladder faculty" (Ernest, 1976, p. 60). Fennema (1980) found that there were sex-related differences in the study of mathematics as indicated by females choosing not to enroll in mathematics courses in high school and by the paucity of females in university mathematics courses. Females also took fewer advanced math courses than male students and were seriously underrepresented in math and science professions (Eccles & Hoffman, 1984; Elmore & Vasu, 1986).

A preponderance of research evidence points to the conclusion that gender differences in mathematics performance do exist (Frost, Hyde, & Fennema, 1994). Leder (1992), offered a conclusion that there is much overlap in the mathematical performance of females and males, but when significant differences occur in performance, they tend to favor males, particularly on higher cognitive level questions. The consequences of these differences, Leder continued, "are compounding and far-reaching, for the differences observed are often accompanied by differences in the ways males and females regard themselves, and are regarded by others, as learners of mathematics. These differences further reinforce and perpetuate inequalities" (Leder, 1992, pp. 608-609). This observation was confirmed by Sells (1980, p. 66) when she stated that "high-school mathematics acts as a critical filter" to limit choices of an undergraduate major for women in general and effectively further limit the opportunities in the world of work. It is believed that the lower achievement by female students in high-cognitive-level tasks is a cause for concern because of the importance of these tasks for success in mathematics in school and the effective use of mathematics outside of school (Hart, 1989).

One of the models that has been proposed to account for the differences highlights the contribution that affect and attitude variables have on the gender gap in performance. Fennema and Peterson (1985) proposed an Autonomous Learning Behavior Model that attributes the development of gender differences in mathematical performance to the failure of children participating in independent learning experiences in mathematics. The learning experiences are determined partly by affect and attitudes. This model was supported by Koehler (1990).

Studies have also confirmed that attitudes play an essential role in the learning of mathematics (Armstrong & Price, 1982; Shaughnessy, Haladyna, & Shaughnessy, 1983; Meyer & Koehler, 1990). McLeod (1992, p. 575) suggests that

> "affective issues play a central role in mathematics learning and instruction. When teachers talk about their mathematics classes they seem just as likely to mention their students' enthusiasm or hostility toward mathematics as to report their cognitive achievements. Similarly, inquiries of students are just as likely to produce affective and cognitive responses; comments about liking (or hating) mathematics are as common as reports of instructional activities. These informal observations support the view that affect plays a significant role in mathematics learning and instruction".

Subsequently, efforts to reform the mathematics curriculum have placed special importance on the role of affect and attitudes. Two of the major goals stated in the standards for curriculum and evaluation (Commission on Standards for School Mathematics, 1989) dealt with helping students to understand the usefulness of mathematics and developing confidence in learning mathematics. Researchers (Suydam & Weaver, 1975; Enemark & Wise, 1981) believe that continual attention should be directed towards creating, developing, maintaining and reinforcing positive attitudes because children learn more effectively when they are interested in what they learn. They will therefore achieve better in mathematics if they like mathematics.

Some studies (Jacobs, 1974; McClure, 1971; Merkel, 1974; Roberts, 1970) however have failed to find significant gender differences in attitudes toward mathematics while others have concluded that indeed, there are gender differences in mathematics-related affect and attitudes (Aiken, 1976; Meyer & Fennema, 1988; Reyes, 1984; Hyde & Fennema, 1990): While affect and attitude toward mathematics are not the only influences on the development of gender differences in mathematics performance, they are important, and both males' and females' affect and attitude should be considered in conjunction with other social and political influences on mathematics performance and gender equity in mathematics education (Hyde & Fennema, 1990).

It has been suggested that "model building may be premature until the two basic premises - that males and females differ in their mathematics performance and that males and females differ in their mathematics-related affect and attitudes have been evaluated with the rigorous, quantitative procedures of meta-analysis" (Frost, Hyde, & Fennema, 1994, p. 374). The purpose of this study therefore is to examine the nature of gender differences in students' attitudes toward mathematics using meta-analysis.. Only one meta-analysis (Hyde, Fennema, Ryan, Frost & Hopp, 1990) that studied gender differences in students' attitude toward mathematics has been located and it covered the period 1967-1988 with an emphasis on the Fennema-Sherman Mathematics Attitudes Scales. The analysis found that

> "overall, effect sizes were small and were similar in size to gender differences in mathematics performance. When differences exist, the pattern is for females to hold more negative attitudes. Gender differences in self-confidence and general mathematics attitudes are larger among high school and college students than among younger students". (Hyde, Fennema, Ryan, Frost & Hopp, 1990, p. 300).

The current study, which covers the period 1970 to 1995, and is a partial update of the Hyde et al. (1990), study addresses the following research questions:

1. What is the magnitude of gender differences in students general attitudes toward mathematics?
2. What is the magnitude of gender differences in students mathematics anxiety?
3. What is the magnitude of gender differences in students mathematics self-confidence/self concept?
4. What is the magnitude of gender differences in students attitude toward mathematics as a male domain?
5. What is the magnitude of gender differences in students attitude toward the usefulness of mathematics?
6. What is the effect of grade level, sample selectivity, year of publication, and source of study on the magnitude of the gender differences in attitudes toward mathematics?

Constructs

Attitude

"A learned disposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person" (Aiken, 1970, p. 551).

Attitude toward mathematics

A liking or disliking of mathematics, a belief that mathematics is easy or difficult, a belief that one is good or bad at mathematics and a tendency to engage in or avoid mathematical activities (Neale, 1969).

Haladyna, Shaughnessy, and Shaughnessy (1983) believe that generally, a positive attitude toward mathematics is valued for the following reasons: "(i) A positive attitude is an important school outcome in and of itself. (ii) Attitude is often positively, although slightly, related to achievement. (iii) A positive attitude toward mathematics may increase one's tendency to elect mathematics courses in high school and college and possibly one's tendency to elect careers in mathematics or mathematics-related fields" (p.20).

Mathematics anxiety

"Involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). Reyes (1984) states that a consistent, negative relationship has been found between mathematics anxiety and

achievement so that high achievement is related to low anxiety for students from grade school through college (Callahan & Glennon, 1975; Betz, 1978).

In a meta analysis of 151 studies, Hembree (1990) concluded that "mathematics anxiety is related to poor performance on mathematics achievement tests. It relates inversely to positive attitudes toward mathematics and is bound directly to avoidance of the subject" (p. 33). Callahan and Glennon (1975) also concluded that anxiety and mathematics are related and "in general high anxiety is associated with lower achievement in mathematics" (p. 82).

Confidence in mathematics

"*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.* Confident students tend to learn more, feel better about themselves, and be more interested in pursuing mathematical ideas than students who lack confidence" (Reyes, 1984, p. 560). It is believed that confidence correlates positively with achievement in mathematics, and the relationship is generally quite strong, with correlation coefficients of greater than 0.40 appearing in studies at the secondary school level (McLeod, 1992; Reyes, 1984; Dowling, 1978). Students who are confident of their ability to learn mathematics are more likely to take mathematics in school when it becomes optional.

Mathematics as a male domain

"*The degree to which students see mathematics as a male, neutral, or female domain in the following ways: (a) the relative ability of the sexes to perform in mathematics; (b) the masculinity/femininity of those who achieve well in mathematics; and the appropriateness of this line of study for the two sexes*" (Fennema, & Sherman, 1976, p. 325). The decision to pursue mathematics can be affected by whether or not a student thinks that studying mathematics is a gender-appropriate activity. If a student believes that mathematics is inappropriate for him/her, the achievement in mathematics could result in a perception that she/he has not adequately fulfilled the gender role.

Usefulness of mathematics

How useful students regard mathematics to be, both for their current need and for their future education, vocation or other activities. (Fennema, & Sherman, 1976; Reyes, 1984). This perceived usefulness determines whether students will elect to take mathematics classes or not. As mathematics becomes optional and increasingly difficult for students, it is likely that they will only continue to engage in its study if they think it will be useful to them. (Meyer & Kohler, 1990).

Method

Description of design

Meta-analysis refers to the analysis of analyses, the statistical analysis of a large collection of analysis results from individual studies with the purpose of integrating the findings. "It connotes a rigorous alternative to the casual, narrative discussions of research studies which typify attempts to make sense of the rapidly expanding research literature"

(Glass, 1976, p. 3). It is also the application of quantitative methods to the problem of combining evidence from different studies (Hedges & Olkin, 1985).

Wolf (1986) stated that meta-analysis addresses the following potential problems associated with traditional literature reviews: "(1) selective inclusion of studies often based on the reviewer's own impressionistic view of the quality of the study; (2) differential subjective weighting of studies in the interpretations of a set of findings; (3) misleading interpretations of study findings; (4) Failure to examine characteristics of the studies as potential explanations for disparate or consistent results across studies; and (5) failure to examine moderating variables in the relationship under examination" (p. 10).

Meta-analysis is not without criticism. Glass, et al. (1981) grouped the criticism of meta-analysis into four categories:

1. The apples and oranges problem. Logical conclusions cannot be drawn by comparing and aggregating studies that include different measuring techniques, definitions of variables and subjects because they are too dissimilar.
2. Results of meta-analyses are uninterpretable because results from "poorly" designed studies are included along with results from "good" studies.
3. The file drawer problem. Published research is biased in favor of significant findings because non significant findings are rarely published.
4. Multiple results from the same study are often used which may bias or invalidate the meta-analysis and make the results appear more reliable than they really are, because these results are not independent.

Attempts have been made in this study to overcome these criticisms and problems.

<u>Selection of sample of studies</u>

The studies for the present investigation were gathered using two main sources: (a) computerized searches of ERIC for the years 1970 to 1995 using the descriptors, "attitude(s)", "belief(s)", "sex differences", "gender differences", "mathematics and attitudes and gender", "mathematics and beliefs and gender", "mathematics and affect and gender", "attitude(s) toward mathematics", "meta-analysis"; and (b) examination of bibliographies, references, and citations from the studies found through the computerized search.

The studies had to satisfy the following criteria for inclusion in the analysis:

1. Conducted in the United States between 1970 and 1995 (both years inclusive).
2. Investigated gender (sex) as a variable.
3. Sufficient quantitative data was reported for the calculation of an effect size.
4. One or more of the following constructs were measured with validated instruments: general attitude towards mathematics, mathematics anxiety, mathematics confidence/self-concept, mathematics as a male domain, and usefulness of mathematics.

A number of studies did not report the statistics needed and were therefore excluded from the analysis. For several of the studies, choices of effect size had to be made since study observations must be independent. Some of the studies tested the same children at more than one age. A random selection procedure was used to determine which result should be used. A body of 96 primary studies: 69 journal articles, and 27 ERIC documents were found. These studies included 30,490 students (15,877 females and 14,613 males).

Coding

The following information was coded for each study:

- identification of author(s)
- grade level (1-5, 6-8, 9-12, college)
- year of publication (1970-1979, 1980-1989, 1990-1995)
- source of study (journal article, ERIC document)
- construct (general attitude, mathematics anxiety, mathematics confidence/self-concept, mathematics as male domain, usefulness of mathematics)
- sample selectivity (remedial, general, gifted)
- sample size (female, male, total)
- means (female, male, overall)
- *t* & *F* statistics, and corresponding degrees of freedom
- standard deviations (female, male, overall)
- mathematical subject (arithmetic, algebra, geometry, trigonometry, calculus, general)
- instrument

The instruments used to measure attitudes toward mathematics were found to vary widely. However, in the selection of the studies, it was decided that only those reporting sound psychometric properties and defining the constructs of interest according to specification would be included in the sample. This is in accordance with Hyde, Fennema, Ryan, Frost, and Hopp's (1990) statement that if "a meta-analysis is to have validity, it is essential that the constructs under examination are reliably and validly measured" (p. 320).

Coding was done independently by the two authors using a code book. Interrater agreement was 0.99 for the first sixty studies. For studies where there were differences, both authors read together to resolve the discrepancies.

Statistical Analysis

The independent variables used for the analysis were (a) grade level, (b) sample selectivity, (c) year of publication, and (d) source of study. The dependent variable was effect size, *d*, (Cohen, 1988; Glass, McGraw, & Smith, 1981; Hedges, 1981) defined as the difference between the mean for males and the mean for females divided by the pooled standard deviation. In this study, the effect-size measure, *d*, uses the formula:

$$d = \frac{\overline{X}_m - \overline{X}_f}{S_f}$$

where $\overline{X}_m$ is the mean of the male scores, $\overline{X}_f$ is the mean of the female scores and S_f, is the standard deviation of the female group. The pooled standard deviation was not used because most of the studies did not report them. To obtain consistency in the results, it was decided to use only the standard deviations of the female scores. In cases where the sample size was less than 50, a correction factor (Hedges, 1981) was used and the formula changed to:

$$d = \left\{1 - \frac{3}{4(df) - 1}\right\} \bullet \left\{\frac{\overline{X}_m - \overline{X}_f}{S_f}\right\}$$

where df is the degrees of freedom. For the studies where the statistic reported was the t, the following formula was used.

$$d = t \bullet \sqrt{\left(\frac{1}{n_m} + \frac{1}{n_f}\right)} \bullet j \quad \text{(Hedges, Shymansky, \& Woodworth, 1986, p. 29-30)}$$

where j is the bias adjustment (correction) factor.

Ninety-five percent (95%) confidence intervals were computed (Hedges & Olkin, 1985) for each mean effect size to test the null hypothesis that the mean effect size was zero or that the two mean effect sizes were equal (Glass & Hopkins, 1984).

Test of homogeneity

The test of homogeneity (Hedges & Olkin, 1985, p. 123; Hedges and Becker, 1986; Hedges et al, 1986) uses the Q-statistic

$$Q = \sum_{i=1}^{k} w_i (d_i - \bar{d})^2 ; \quad \bar{d} = \frac{\sum_{i=1}^{k} w_i d_i}{\sum_{i=1}^{k} w_i} ; \text{ and } \quad w_i = \frac{n_m + n_f}{n_m n_f} + \frac{d_i^2}{2(n_m + n_f - 2)}$$

where w_i is the reciprocal of the estimated variance of d_i (the effect size of each study), $\bar{d}$ is the weighted mean of the d_i's. The statistic, Q, is asymptotically distributed as a chi-square with k-1 degrees of freedom (where k is the number of studies). If Q is not statistically significant at a specified alpha level, the group is homogenous.

Model used

The random effects model was used for the analysis. As Hedges (1992) pointed out, the "random effects conception arises from a model in which the treatment effects are not deterministic functions of known study characteristics. In this model, the true or population values of treatment effects vary randomly from study to study, as if they were sampled from a universe of possible treatment effects" (p. 285).

Results

Overall attitude toward mathematics

Table 1 shows the weighted effect sizes for all five constructs. Though females showed a more positive general attitude toward mathematics, ($\bar{d}_w$ = -0.012), overall the gender difference was small. Females also experienced more mathematics anxiety ($\bar{d}_w$ = -0.182). The males showed more self-confidence in mathematics ($\bar{d}_w$ = +0.179) and were more likely to consider mathematics a male domain ($\bar{d}_w$ = +0.121). However, the differences are small and not statistically significant. The homogeneity analysis showed that all the groups were homogenous.

Under the assumption that the two populations are normal with equal size and variability, there is only a nonoverlap of 1.6% between females and males in the general attitude toward mathematics. A nonoverlap of 13.4% is found in mathematics anxiety and self-confidence in mathematics. Mathematics as a male domain yielded a nonoverlap of 9.1% and there is a nonoverlap of about 1% in the usefulness of mathematics.

Table 1
Overall magnitude of gender differences

Construct	No. of effect sizes	No. of students Female	Male	Effect Size $\overline{d}_w$	$Se_{\overline{d}}$	Confidence Interval	Q*
Attitude	18	6951	6564	-0.012	0.05	-0.13, +0.10	18.65
Anxiety	20	5670	4699	-0.182	0.14	-0.48, +0.12	18.24
Confidence	24	6932	6607	+0.179	0.03	+0.11, +0.25	24.28
Male Domain	17	4223	3839	+0.121	0.31	-0.54, +0.78	15.82
Usefulness	17	4649	4152	-0.005	0.05	-0.15, +0.04	12.30

* Homogeneity coefficient

General attitudes toward mathematics

Gender differences in the general attitude toward mathematics by the selected variables is reported in Table 2. Generally the weighted mean effect sizes are small. It must be noted however that in the lower grades, 1-5 and 6-8, females showed more positive attitudes toward mathematics. This changed in the upper levels (i.e. grades 9-12 and college) where the males showed more positive attitudes. A trend which should be noted is that in the 1970 -1979 analysis, males showed a more positive attitude ($\overline{d}_w$ = +0.20) but in the 1990-1995 analysis, females showed a slightly more positive attitude ($\overline{d}_w$ = -0.10).

Further analysis through t-tests for mean differences in the source of document (Table 2.1) and the analysis of variances for the grade, selectivity, and year variables (Table 2.2) did not yield any additional information. None of the results were significant.

Insert Tables 2, 2.1 & 2.2 about here

Mathematics anxiety

The weighted effect sizes, t-test for mean differences and the analysis of variance results are shown in Tables 3, 3.1 and 3.2 respectively. Homogeneity analysis shows that the effect sizes for the groups within each construct are homogenous. Neither the t-test nor the analysis of variance produced any significant results.

At all grade levels, females showed more mathematics anxiety than the males especially in grades 9-12 ($\overline{d}_w$ = -0.19) and college ($\overline{d}_w$ = -0.20). There was however, a difference in the sample selectivity group. In the remedial group, the males showed more anxiety ($\overline{d}_w$ =+0.25) whereas the females showed more anxiety in the general group ($\overline{d}_w$ = -0.27). During the 1970-1979 time period, males showed more anxiety but in subsequent years, the females showed more anxiety. In both sources of study (journal & ERIC), females showed more mathematics anxiety.

Insert Tables 3, 3.1 & 3.2 about here

Mathematics confidence/self-concept

Gender differences in mathematics confidence/self-concept by the various variables are reported in Table 4. For all variables, especially grades 1-5 ($\overline{d}_w$ =+0.25), and college ($\overline{d}_w$ =+0.26), and the remedial group ($\overline{d}_w$ =+0.30), males showed more confidence in learning mathematics. However, for grade level 6-8, ($\overline{d}_w$ =+0.19), and general selectivity category ($\overline{d}_w$ =+0.09), significant mean differences were found. In addition, time periods 1970-1979 ($\overline{d}_w$ =+0.20), and 1990-1995 ($\overline{d}_w$ =+0.18) and journal source ($\overline{d}_w$ =+0.18), also produced significant mean differences. Analysis of variance (ANOVA) and t-tests (see Tables 4.1, & 4.2) did not show any significant mean differences.

Insert Tables 4, 4.1 & 4.2 about here

Mathematics as a male domain

Table 5 presents the magnitude of gender differences in mathematics as a male domain. It was found that males in grades 1-5 ($\overline{d}_w$ =+0.31), 6-8 ($\overline{d}_w$ =+0.18), and 9-12 ($\overline{d}_w$ =+0.45), are more likely to consider mathematics as a male domain while at the college level ($\overline{d}_w$ =-0.51), females are more likely to consider it as such. In the general selectivity group, males considered mathematics as a domain for them but in the time periods 1980-1989 ($\overline{d}_w$ =-0.24), and 1990-1995 ($\overline{d}_w$ =-0.47), females considered mathematics as a domain for males. The journal articles found that males considered mathematics as their domain ($\overline{d}_w$ =+0.53), but in the ERIC documents, the results showed that females took mathematics to be a male domain. Analysis of variance (ANOVA) results and t-tests for mean differences (Tables 5.1 & 5.2) did not produce any significant results.

Insert Table 5, 5.1 & 5.2 about here

Usefulness of mathematics

The analyses of the usefulness of mathematics variable is listed in Tables 6, 6.1, and 6.2. Generally, the effect sizes are very small ranging from 0.01 to 0.19 with the majority (8 out of 11) being below 0.10. A notable result is that for grades 1-5 ($\overline{d}_w$ =-0.14) and at the college level ($\overline{d}_w$ =-0.19), females were found to regard mathematics more useful than males. However, analysis of variance (ANOVA) and t-tests did not yield any significant results.

Insert Table 6, 6.1 & 6.2 about here

Discussion

This study involved the analysis of 96 effect sizes obtained from 15,877 females and 14,613 males. Cohen & Cohen (1983) reported that effect sizes of the magnitude of 0.2 and above are of practical importance in the behavioral sciences. Cohen (1988) suggested further that conventionally, in the face of relativity in the behavioral sciences, effect sizes can be classified as small (d = 0.2), medium (d = 0.5) and large (d = 0.8). When populations are normally distributed and have equal size and variability, those with small effect size have 14.7% of their combined area not overlapped. Medium effect size results in 33% of non-overlap and for large effect size 47.4% of their areas are not overlapped. However results must be interpreted with the caution given that

> "despite the growing awareness of the importance of estimating effect sizes, there is a problem of evaluating various effect size estimators from the point of view of practical usefulness..........neither experienced behavioral researchers nor experienced statisticians had a good intuitive feel for the practical meaning of common effect size estimators" (Cooper & Hedges, 1994, pp. 241-242).

General attitude toward mathematics

The results for grade levels partially confirms that there are gender differences in mathematics-related affect and attitudes (Aiken, 1976; Meyer & Fennema, 1988; Reyes, 1984; Hyde & Fennema, 1990). For the elementary school studies, the effect sizes were generally found to be small (0.20) yet favoring females. The noteworthy effect size is +0.23 for grades 9-12 which favors males.

The high school (grade 9-12) results are similar to those of Hyde et. al (1990) where an effect size of +0.17 was found. One possible explanation for this outcome could be that females hold stereotypical views of mathematics as a male domain and this deters them from putting a greater effort into studying mathematics. Benbow & Stanley (1980) proposed that the differences in attitude toward mathematics result from superior mathematical ability which "is probably an expression of a combination of both endogenous and exogenous variables" (p. 1264). The classroom environment might also explain the differences as teachers are more apt to involve males in mathematical tasks than females.

Aiken (1976) suggested that the difference might be due to a lack of success in mathematics for females. It has also been found that parents, and counselors provide more explicit rewards, encouragement, and reinforcement to males for learning mathematics and for considering mathematics-related careers than females (Stage et al. 1985; Parsons, Kaczala, & Meece, 1982).

An overall trend in the attitude toward mathematics seems to appear over the years. Attitude toward mathematics favored males (+0.20) in the period 1970-1979 but dropped to +0.05 during 1980-1989 and changed to favor females (-0.10) from 1990 -1995. Though this result is not statistically significant, it provides some indication of the success of the efforts to change females' attitude toward mathematics. But we do agree with Aiken (1976) that "changes in attitude toward mathematics involve a complex interaction among student and teacher characteristics, course content, method of instruction, instructional materials, parental and peer support" (p. 302).

Mathematics anxiety

Generally, the results show that females experience more mathematics anxiety than males in the high school years and beyond. Though the effect sizes are small (-0.19, -0.20), the difference is of practical importance because of the view that this anxiety keeps females out of mathematics-related courses and careers (Hyde et al., 1990). In addition, since negative anxiety is related to poor performance on mathematics achievement tests (Hembree, 1990), it is imperative that increased efforts are employed to encourage females to study mathematics. The good news is that since 1980, the gap appears to be closing indicating some success with the anxiety-reducing efforts.

Mathematics confidence and self-concept

The overall result indicates that males have higher self-confidence in mathematics than females. The effect sizes, though small, have some practical considerations. McLeod (1992), reported that confidence correlates positively with achievement in mathematics therefore one of the ways to improve upon the achievement level of females in mathematics is to raise their confidence level. Teachers and parents efforts at school and home may be critical in this situation.

Mathematics as a male domain

The current study supports the Hyde et al. (1990) findings that males are more likely to stereotype mathematics as a male domain than females at the high school level and below. At the college level, however, females stereotype mathematics as a male domain more than males. This result may be one explanation for the fewer number of females in mathematics-related courses at the college level and careers. Since females hold the view that those courses are in the male domain, their desire to get involved is reduced. On the other hand, in the high school where males stereotype mathematics as their domain, male peers of female students "indicate in a variety of subtle ways that females who achieve in mathematics are somehow less feminine and thus put pressure on females not to achieve in mathematics" (Hyde et al. 1990, p. 310).

Usefulness of mathematics

No striking gender differences emerged in this portion of the study. The effect sizes were very small indicating that both males and females regard mathematics as a useful area of study. These results do not support the theory that the negative attitudes of females toward mathematics is due to the fact that they find mathematics less useful than males do.

Conclusion

The major conclusions in this study are that gender differences in students attitudes toward mathematics do exist but are small in size. They mainly favor males indicating more positive attitudes toward mathematics. However, since the differences are small in size, the proposition that it is the students attitude toward mathematics that mainly accounts for the gender differences in mathematics performance may not be absolutely correct. This study however is limited to only two sources of information and therefore more evidence is needed to confirm these results. The inclusion of studies from doctoral dissertations and other additional sources may provide additional insight. To explain the differences in mathematical task performances, other factors and influences must be examined. Since the differences do not seem to appear in the early years, the causal relationship between attitudes and performance in mathematics needs further study.

Do males perform better than females at mathematical tasks *because* they have positive attitudes, are more self-confident in learning mathematics and regard mathematics as their domain?

Do males have positive attitudes, are more self-confident in learning mathematics and regard mathematics as their domain *because* they perform well in mathematics?

Do females perform worse at mathematical tasks *because* they have negative attitudes, are less self-confident in learning mathematics and regard mathematics as a male domain?

Do females have negative attitudes, are less self-confident in learning mathematics and regard mathematics as a male domain *because* they perform worse in mathematics?

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Table 2
Magnitude of gender differences for general attitude toward mathematics

Construct	No. of effect sizes	No. of students Female	Male	Effect Size $\overline{d}_w$	$Se_{\overline{d}}$	Confidence Interval	Q*
Grade							
1 - 5	5	417	411	-0.18	0.07	-0.37, +0.02	1.31
6 - 8	5	700	685	-0.15	0.11	-0.47, +0.16	3.91
9 - 12	2	4184	4042	+0.23	0.07	-0.66, +1.11	0.99
college	6	1650	1426	+0.11	0.08	-0.09, +0.31	5.03
Selectivity							
remedial	1	95	141	-0.04	0.13	na	na
general	16	6832	6399	-0.02	0.06	-0.15, +0.11	15.65
gifted	1	24	24	+0.21	0.29	na	na
Year							
1970 - 1979	4	668	557	+0.20	0.13	-0.21, +0.60	2.83
1980 - 1989	4	4823	4607	+0.05	0.02	-0.02, +0.11	4.92
1990 - 1995	10	1460	1400	-0.10	0.07	-0.26, +0.07	9.79
Source							
journal	16	2861	2604	-0.03	0.06	-0.15, +0.10	16.05
ERIC	2	4090	3960	+0.06	0.02	-0.22, +0.35	0.26

* Homogeneity coefficient

Table 2.1
t-test for equality of means for attitude toward mathematics

Variable	df	Mean diff	SE of Diff	t-value	p
Source of study	16	-0.1736	0.178	-0.97	0.345

Table 2.2
ANOVA results for attitude toward mathematics

Variable	Source	df	SS	MS	F	p
Grade	Between	3	0.3978	0.1326	3.3194	0.0510
	Within	14	0.5593	0.0399		
Selectivity	Between	2	0.0554	0.0277	0.4612	0.6392
	Within	15	0.9016	0.0601		
Year	Between	2	0.2124	0.1062	2.1386	0.1524
	Within	15	0.7447	0.0496		

Table 3
Magnitude of gender differences for mathematics anxiety

Construct	No. of effect sizes	No. of students Female	Male	Effect Size $\bar{d}_w$	$Se_{\bar{d}}$	Confidence Interval	Q*
Grade							
1 - 5	-	-	-	-	-	-	-
6 - 8	4	2440	2100	-0.09	0.03	-0.18, +0.01	2.88
9 - 12	3	1053	953	-0.19	0.23	-1.17, +0.79	1.94
college	13	2177	1646	--0.20	0.22	-0.67, +0.28	11.75
Selectivity							
remedial	3	333	319	+0.25	0.20	-0.60, +1.09	2.11
general	16	5265	4335	-0.27	0.17	-0.63, +0.08	14.43
gifted	1	72	45	-0.08	na	na	na
Year							
1970 - 1979	4	417	417	+0.15	0.17	-0.41, +0.70	3.02
1980 - 1989	9	1611	1148	-0.30	0.30	-1.00, +0.39	7.90
1990 - 1995	7	3642	3134	-0.22	0.06	-0.37, -0.06	6.25
Source							
journal	17	4566	3664	-0.18	0.17	-0.54, +0.18	15.52
ERIC	3	1104	1035	-0.19	0.04	-0.19, 0.00	1.23

* Homogeneity coefficient

Table 3.1
t-test for equality of means for mathematics anxiety

Variable	df	Mean diff	SE of Diff	t-value	p
Source of study	18	0.0190	0.409	0.05	0.963

Table 3.2
ANOVA results for mathematics anxiety

Variable	Source	df	SS	MS	F	p
Grade	Between	2	0.0093	0.0046	0.0102	0.9898
	Within	17	7.6779	0.4516		
Selectivity	Between	2	0.7604	0.3802	0.9331	0.4126
	Within	17	6.9268	0.4075		
Year	Between	2	0.6273	0.3136	0.7552	0.4850
	Within	17	7.0599	0.4153		

Table 4
Magnitude of gender differences for self-confidence

Construct	No. of effect sizes	No. of students		Effect Size		Confidence Interval	Q*
		Female	Male	$\bar{d}_w$	$Se_{\bar{d}}$		
Grade							
1 - 5	3	642	616	+0.25	0.06	-0.01, +0.51	1.62
6 - 8	13	5107	4820	**+0.19**	0.06	-0.31, -0.07	**57.72**
9 - 12	6	1017	1010	+0.16	0.04	+0.04, +0.27	3.15
college	2	166	161	+0.26	0.16	-1.80, +2.31	0.98
Selectivity							
remedial	2	526	483	+0.30	0.06	-0.51, +1.10	0.67
general	18	5676	5298	**+0.09**	0.02	+0.05, +0.13	**48.71**
gifted	4	730	826	+0.21	0.18	-0.38, +0.79	2.57
Year							
1970 - 1979	5	392	483	**+0.20**	0.07	+0.01, +0.39	1.38
1980 - 1989	7	668	610	+0.19	0.10	-0.05, +0.44	5.58
1990 - 1995	12	5872	5514	**+0.18**	0.05	+0.08, +0.29	11.43
Source							
journal	15	4444	4136	**+0.18**	0.03	+0.11, +0.25	23.56
ERIC	9	2488	2471	+0.17	0.07	0.00, +0.34	6.76

* Homogeneity coefficient

Bold numbers indicate significant differences at $p < 0.05$

Table 4.1
t-test for equality of means for self-confidence in mathematics

Variable	df	Mean diff	SE of Diff	t-value	p
Source of study	22	-0.0208	0.087	-0.24	0.814

Table 4.2
ANOVA results for self-confidence in mathematics

Variable	Source	df	SS	MS	F	p
Grade	Between	3	0.0844	0.0281	0.6517	0.5912
	Within	20	0.8633	0.0432		
Selectivity	Between	2	0.0593	0.0296	0.7007	0.5075
	Within	21	0.8884	0.0423		
Year	Between	2	0.0115	0.0057	0.1286	0.8800
	Within	21	0.9363	0.0446		

Table 5
Magnitude of gender differences for mathematics as male domain

Construct	No. of effect sizes	No. of students Female	Male	Effect Size $\overline{d}_w$	$Se_{\bar{d}}$	Confidence Interval	Q*
Grade							
1 - 5	1	104	96	+0.31	0.14	na	na
6 - 8	8	2881	2564	+0.18	0.39	-0.89, +0.93	11.05
9 - 12	6	1042	1009	+0.45	0.61	-1.12, +2.02	4.99
college	2	196	170	-0.51	0.11	-1.88, +0.86	0.39
Selectivity							
remedial	-	-	-	-	-	-	-
general	14	3979	3581	+0.15	0.36	-0.62, +0.92	12.82
gifted	3	244	258	-0.02	0.70	-3.04, +3.01	2.02
Year							
1970 - 1979	5	417	482	+0.07	0.75	-2.02, +2.15	3.96
1980 - 1989	6	432	386	-0.24	0.52	-1.57, +1.09	4.90
1990 - 1995	6	3374	2971	**-0.47**	0.03	-0.54, -0.40	**1631**
Source							
journal	10	3017	2631	+0.53	0.40	-0.37, +1.44	9.04
ERIC	7	1206	1208	-0.47	0.42	-1.51, +0.56	5.85

* Homogeneity coefficient

Bold numbers indicate significant differences at $p < 0.05$

Table 5.1
t-test for equality of means for mathematics as a male domain

Variable	df	Mean diff	SE of Diff	t-value	p
Selectivity	15	0.1433	0.841	0.17	0.867
Source of study	22	-0.0208	0.087	-0.24	0.814

Table 5.2
ANOVA results for mathematics as a male domain

Variable	Source	df	SS	MS	F	p
Grade	Between	3	1.6237	0.5412	0.2856	0.8350
	Within	13	24.6387	1.8953		
Year	Between	2	1.9307	0.9654	0.5555	0.5860
	Within	14	24.3316	1.7380		

Table 6
Magnitude of gender differences for usefulness of mathematics

Construct	No. of effect sizes	No. of students Female	Male	Effect Size $\overline{d}_w$	$Se_{\overline{d}}$	Confidence Interval	Q*
Grade							
1 - 5	1	444	420	-0.14	0.07	na	na
6 - 8	8	2881	2564	-0.05	0.08	-0.23, +0.14	5.47
9 - 12	6	984	1000	+0.05	0.05	-0.06, +0.17	3.15
college	2	340	168	-0.19	0.10	-1.46, +1.08	0.44
Selectivity							
remedial	-	-	-	-	-	-	-
general	14	4405	3894	-0.05	0.06	-0.18, +0.07	9.44
gifted	3	244	258	-0.01	0.09	-0.39, +0.38	0.43
Year							
1970 - 1979	5	359	473	-0.10	0.09	-0.35, +0.15	2.95
1980 - 1989	5	472	288	-0.09	0.08	-0.31, +0.13	4.94
1990 - 1995	7	3818	3391	-0.04	0.08	-0.24, +0.16	4.77
Source							
journal	11	3547	3040	-0.05	0.07	-0.20, +0.10	7.78
ERIC	6	1102	1112	+0.03	0.04	-0.08, +0.14	4.09

* Homogeneity coefficient

Table 6.1
t-test for equality of means for usefulness of mathematics

Variable	df	Mean diff	SE of Diff	t-value	p
Selectivity	15	-0.0224	0.157	-0.14	0.889
Source of study	15	0.1207	0.122	0.99	0.337

Table 6.2
ANOVA results for usefulness of mathematics

Variable	Source	df	SS	MS	F	p
Grade	Between	3	0.1421	0.0474	0.7950	0.5182
	Within	13	0.7744	0.0596		
Year	Between	2	0.1053	0.0526	0.9085	0.4256
	Within	14	0.8112	0.0579		

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