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ABSTRACT

The attitudes toward mathematics of a large cross-sectional sample of students in grades 6 through 12 were explored. Most previous studies have not used samples as large as the 623 urban public school students in the southern United States, included in this study. The sample included 55.1 percent females, 58.3 percent Whites, 27.6 percent African Americans, and 7.4 percent Hispanics. Grades 7 and 8 were oversampled because they are important transition years in the educational process. Students' attitudes were assessed with 75 items from the Fennema-Sherman Mathematics Attitudes Scales. Surprisingly, females generally had more positive attitudes toward mathematics, but were also more anxious about mathematics than were males. The effects associated with grade level were less noteworthy, but there was some tendency over increases in grade levels for subjects to perceive fathers to be somewhat less supportive of mathematics as an important area and for subjects to become somewhat more anxious about mathematics. Five tables present study findings. An appendix lists item stems and scale classifications. (Author/SLD)

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How Elementary School Children Think About Mathematics

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ABSTRACT

The present study was conducted to explore the attitudes of a large cross-sectional sample of sixth- through twelfth-graders. Most previous studies have not employed such samples. Surprisingly, females generally had more positive attitudes toward mathematics, but were also more anxious about math. The effects associated with grade level were less noteworthy, but there was some tendency over increases in grade levels for subjects to perceive fathers to be somewhat less supportive of mathematics as an important area and for subjects to become somewhat more anxious about mathematics.

For at least 15 years there has been considerable interest in attitudes toward the study of mathematics and in the correlates of these attitudes (Sherman & Fennema, 1977). There have been longstanding controversies regarding (a) the origins of gender differences in mathematics achievement (Fennema, 1981), (b) the origins of the limited participation of women in mathematics-related occupations (e.g., Fennema, Wolleat, Pedro & Becker, 1981), and (c) whether or not males and females are treated differently by teachers during mathematics instruction (e.g., Becker, 1981).

The present study was conducted to explore the attitudes towards mathematics of a large cross-sectional cohort of students in grades six through twelve. Specifically, the study was conducted to address three research questions:

1. What are the reliabilities of scores on measures of students' attitudes towards mathematics?
2. What gender differences, if any, are there across scales measuring students' attitudes towards mathematics?
3. What differences, if any, are there across grade levels on scales measuring students' attitudes towards mathematics?

Method

Subjects

The sample consisted of 623 students enrolled in public schools in an urban school district in the southern United States. The students were enrolled in grades six through twelve, though the grades seven and eight were oversampled because they are important transition years in the educational process. The breakdown of the sample across grade levels was: (a) grade six, *n*=28 (4.5%), (b) grade seven, *n*=209 (33.5%), (c) grade eight, *n*=173 (27.8%), (d) grade nine, *n*=81 (13.0%), (e) grade ten, *n*=53 (8.5%), (f) grade eleven, *n*=60 (9.6%), and (g) grade twelve, *n*=19 (3.0%).

There were somewhat more females (55.1%) in the sample. The sample included members of various ethnic groups, including: (a) whites (58.3%), (b) African Americans (27.6%), and (c) Hispanics (7.4%).

Instrumentation

The Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) are among the most popular measures used studies of attitudes towards mathematics. For the purposes of the present study a subset of 75 of these items were employed. Some wording changes were made to accommodate the use of the items in the range of grade levels considered in the study. The item response format was "yes-no". The item stems and scale classifications are summarized in Appendix A.

Results

1. Reliability Analyses

As Kerlinger (1986) noted, "Poor measurement can invalidate any scientific investigation. There is growing understanding that all measuring instruments must be critically and empirically examined for their reliability and validity" (p. 431). Sexton, Thompson, Scott, and Wood (1990) stated that "psychometric properties... [of scores] are critical ...because incorrect conclusions will be extrapolated from studies employing inadequate measures" (p. 37).

To be specific, the reliability coefficients for data establish an upper bound on the effect sizes that can be detected in any study. For example, a correlation coefficient cannot exceed the square root of the product of the two reliability coefficients for the two sets of scores being correlated (Locke, Spirduso, & Silverman, 1987). In this context, as Snyder, Lawson, Thompson, Stricklin, and Sexton (in press, emphasis added) point out:

> Thus, reliability coefficients for the data obtained on study instruments used in the empirical investigation *prospectively* provide a basis for determining, a priori, whether a proposed study and substantive analyses are even plausible. These coefficients also allow the researcher to *retrospectively* interpret obtained effect sizes (e.g., r^2) against the ceiling created by the reliability coefficients obtained for scores on instruments in a study.

However, **characteristics of measurement integrity relate to the scores or the data from the sample on which they were obtained, and <u>not</u> to the test itself.** As Sax (1980) stated:

> It is more accurate to talk about the reliability of <u>measurements</u> (data, scores, and observations) than the reliability of <u>tests</u> (questions, items, and other tasks). Tests cannot be stable or unstable, but observations can. Any reference to the

"reliability of a test" should always be interpreted to mean the "reliability of measurements or observations [i.e., a particular set of data] derived from a test". (p. 261)

Similarly, Rowley (1976, p. 53) notes that, "It needs to be established that an instrument itself is neither reliable nor unreliable." And Eason (1991, p. 84) points out that, "Though some practitioners of the classical measurement paradigm speak of reliability as a characteristic of tests, in fact reliability is a characteristic of data, albeit data generated on a given measure administered with a given protocol to given subjects on given occasions."

Strictly speaking, it is imprecise to say, "The test is reliable." There is no harm in such misspeaking, as long as our behavior does not imply that we believe that tests themselves can be reliable and valid. As Thompson (1992b) noted, "This is not just an issue of sloppy speaking--the problem is that sometimes we come to think what we say or what we hear, so that sloppy speaking does sometimes lead to a more pernicious outcome, sloppy thinking and sloppy practice" (p. 436).

Classical theory alpha coefficients were computed to investigate the measurement integrity of the scores from the attitude scales. This theory is a special case of generalizability theory (Eason, 1991; Shavelson, Webb & Rowley, 1989; Thompson, 1992a). Table 1 presents the alpha coefficients for scores on the scales. Scores on six scales had sufficient reliability to be employed in subsequent substantive analyses.

INSERT TABLE 1 ABOUT HERE

2. Gender-Related Differences in Scale Means

Table 2 presents descriptive statistics for the comparisons across gender. Multivariate methods were employed to avoid inflation of experimentwise Type I error rates (Fish, 1988). The analysis invoked MANOVA conducted as a Descriptive Discriminant Analysis (DDA) (Huberty & Barton, 1989; Huberty & Wisenbaker, 1992).

INSERT TABLE 2 ABOUT HERE

The multivariate test of group differences on the two sets of six scale scores was statistically significant (λ=.88, F=13.50, df=6/614, p<.001). The effect size associated with this difference, analogous to r^2 or eta^2, was 12%.

Some researchers use multiple univariate ANOVAs as a post hoc procedure following the finding of a statistically significant omnibus multivariate effect. This procedure does not control the inflation of experimentwise error rate, nor does the analysis focus on the synthetic composite variables actually analyzed in DDA, and thus is inappropriate (Maxwell, 1992, pp. 138-139). When DDA is employed, standardized function and structure coefficients provide the basis for result interpretation. These results are presented in Table 3.

INSERT TABLE 3 ABOUT HERE

3. Grade-Related Differences in Scale Means

Table 4 presents descriptive statistics for the comparisons across grade levels. The multivariate test of group differences on the seven sets of six scale scores was statistically significant (λ=.85, F=2.77, df=36/2681.46, p<.001). The effect size associated with this difference, analogous to r^2 or eta^2, was 2.5% (Maxwell, 1992, p. 165). Table 5 presents the standardized function and structure coefficients associated with this analysis.

INSERT TABLES 4 AND 5 ABOUT HERE

Discussion

It was somewhat surprising that scores on two of the scales, Confidence in Learning Mathematics and Attitude Toward Success in Mathematics, had insufficient reliability to be used in substantive analyses, as reported in Table 1. However, the basis for the result is relatively clear.

Score reliability is a function of score variance. The reason why longer tests can yield more reliable scores than shorter tests is that longer tests *tend* to yield more variability in scores. Similarly, scores from tests administered to more heterogenous subjects *tend* to be more reliable than scores administered to more homogeneous subjects, because more heterogeneous samples tend to have scores that are more variable.

In the present study, the variances for the Confidence in Learning Mathematics (9 items) and Attitude Toward Success in Mathematics (6 items) scales were .78 and .99, respectively. The subjects' attitudes on these items were simply too similar to yield sufficient score variance. In future research, this might be compensated for by using more items on each scale.

With respect to the research question involving gender differences, it was surprising to find that the females had more positive attitudes on all the scales, except Anxiety, though the univariate differences in means on the Usefulness scale was not statistically significant, as reported in Table 2. Thus, the females in the present study felt somewhat more encouraged regarding mathematics by their fathers and by their teachers, did not see math as a male domain, and had more effectance motivation than did their male counterparts. However, notwithstanding these patterns, the female subjects were also more likely to be more anxious about mathematics than were their male counterparts. This paradox suggests some conflict regarding performance in math. The multivariate results reported in Table 3 suggest similar interpretations, though the results indicate that the largest differences occurred as a function of scores on the Male Domain and Anxiety scales.

With respect to cross-sectional analysis of grade level effects, the effect size (2.5%) was minimal in magnitude. As suggested by results reported in Tables 4 and 5, perhaps the most noteworthy differences involved scores on the Father and the

Anxiety scales. Scores on both sets of scales tended to decrease over time. Thus, fathers were seen as less supportive of or involved in mathematics as a subject (and possibly school subjects generally) over time, and subjects felt more anxious at higher grade levels. The first pattern may reflect a pattern of disengagement from parental influence with age; the second pattern may reflect a recognition that mathematics concepts become increasingly complex and elegant at higher grade levels.

In summary, the present study was conducted to explore the attitudes of a large cross-sectional sample of sixth- through twelfth-graders. Most previous studies have not employed such samples. Surprisingly, females generally had more positive attitudes toward mathematics, but were also more anxious about math. The effects associated with grade level were less noteworthy, but there was some tendency over increases in grade levels for subjects to perceive fathers to be somewhat less supportive of mathem·tics as an important area and for subjects to become somewhat more anxious about mathematics.

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Table 1
alpha Coefficients for the Scales

Scale	alpha
Confidence in Learning Mathematics (C)	<.05
Father (F)	**.77**
Attitude Toward Success in Mathematics (AS)	.45
Teacher (T)	**.70**
Mathematics as a Male Domain (MD)	**.76**
Usefullness of Mathematics (U)	**.80**
Anxiety(A)	**.80**
Effectance Motivation in Mathematics (E)	**.71**

Note. **Bolded** scales were retained for use in substantive analyses.

Table 2
Scale Means (and Standard Deviations) across Gender

	Gender		
Scale	Females	Males	
Father (F)	6.16	5.70	*
	(2.04)	(2.24)	
Teacher (T)	5.90	5.25	*
	(1.82)	(2.14)	
Male Domain (MD)	8.90	7.84	*
	(1.52)	(2.34)	
Usefullness (U)	6.79	6.52	
	(1.78)	(2.03)	
Anxiety (A)	4.74	5.38	*
	(2.61)	(2.27)	
Effectance Motivation (E)	5.80	5.23	*
	(2.33)	(2.25)	

* $p < .05$

Table 3
Standardized Function and Structure Coefficients
for MANOVA via DDA Predicting Gender

Scale	Function	r_s
Father (F)	-0.18	-0.30
Teacher (T)	-0.29	-0.45
Male Domain (MD)	-0.68	-0.78
Usefullness (U)	0.11	-0.19
Anxiety (A)	0.56	0.35
Effectance Motivation (E)	-0.37	-0.34

Table 4
Scale Means (and Standard Deviations) across Grade Levels

Scale	Grade Level 6	7	8	9	10	11	12	
Father (F)	6.28	6.28	6.10	5.93	5.11	5.15	5.95	*
	(1.99)	(2.09)	(1.94)	(2.09)	(2.44)	(2.34)	(2.22)	
Teacher (T)	6.08	5.82	5.48	5.61	4.87	5.65	6.15	*
	(1.96)	(1.84)	(2.05)	(2.28)	(1.96)	(2.04)	(1.11)	
Male Domain (MD)	8.87	8.38	8.19	8.87	8.13	8.74	8.90	
	(1.26)	(2.11)	(2.05)	(1.52)	(2.37)	(1.79)	(1.56)	
Usefullness (U)	6.89	7.01	6.62	6.96	5.78	5.96	6.63	*
	(2.28)	(1.48)	(1.95)	(1.38)	(2.21)	(2.48)	(2.54)	
Anxiety (A)	6.58	5.58	4.89	4.11	4.88	4.54	3.84	*
	(2.00)	(2.25)	(2.41)	(2.63)	(2.48)	(2.69)	(2.75)	
Effectance Motivation (E)	5.83	5.87	5.43	5.59	4.98	5.09	5.70	*
	(2.16)	(2.27)	(2.39)	(2.29)	(2.30)	(2.26)	(2.16)	

* $p < .05$

Table 5
Standardized Function and Structure Coefficients
for MANOVA via DDA Predicting Grade Levels

	Function I		Function II	
Scale	Function	r_s	Function	r_s
Father (F)	-0.43	-0.55	-0.21	-0.48
Teacher (T)	0.04	-0.24	-0.19	-0.36
Male Domain (MD)	0.19	0.14	-0.12	-0.30
Usefullness (U)	-0.36	-0.52	-0.59	-0.72
Anxiety (A)	-0.78	-0.79	0.66	0.46
Effectance Motivation (E)	0.14	-0.35	-0.20	-0.33

Appendix A
Item Stems and Scale Classifications

V01 AS+03 I'd be happy to get top grades in mathematics
V02 AS+04 It would be rally great to win a prize in mathematics
V03 AS-11 people like me less if I were really good math student
V04 AS+06 Being regarded as smart in math would be really good thing
V05 AS-08 People think I some kind of a nerd if I got A's in math
V06 AS-12 I don't like people to think I'm smart in mathematics
V07 T-11 tchrs think wasn't serious if told I interst career sci/math
V08 T+01 My teachers have encouraged me to take more mathematics
V09 T+04 My math teachers have encouraged me in mathematics
V10 T-08 I have found it hard to win the respect of math teachers
V11 T+02 Math teachers made me feel I could do well in math courses
V12 T-07 comes anything serious, felt ignored talk to math teachers
V13 T-10 Get math teacher take me seriously usually been a problem
V14 T+06 I would talk to my math teachers about career uses math
V15 MD-07 It's hard to believe a female could be a genius in math
V16 MD+01 Females are just as good as males in mathematics
V17 MD+03 would trust woman just much as man to figure import calcs
V18 MD-09 would have more faith answer to math prob solved by a boy
V19 MD+04 Girls can do just as well as boys in mathematics
V20 MD+05 Males are not naturally better than females in math
V21 MD-12 would expect woman mathematician to be a masculine type
V22 MD-10 Girls who enjoy studying math are a bit peculiar
V23 MD+06 Women are certainly logical enough to do well in math
V24 MD-08 When woman has solve math prob, is feminine ask man help
V25 AX+01 Math doesn't scare me at all
V26 AX-09 get sinking feeling when think of try hard math problems
V27 AX-10 mind goes blank & unable think clear when working math
V28 AX+03 haven't usually worried bout be able solve math problems
V29 AX+04 I almost have never gotten shook up during a math test
V30 AX+06 I am usually at ease in math class
V31 AX-11 A math test generally scares me
V32 AX-08 Mathematics makes me uncomfortable, nervous, restless and
V33 U+01 I'll need mathematics for my future work
V34 U+02 I study mathematics because I know how useful it is
V35 U-12 I expect have little use for math when I get out of school
V36 U-08 Mathematics will not be important to me in my life's work
V37 U+06 I will use mathematics in many ways in my adult life
V38 U-10 Taking math is a waste of time
V39 U-11 terms of adult life, not import me do well math in hi sch
V40 U+03 Knowing mathematics will help me earn a living
V41 E-07 Figuring out math problems does not appeal to me
V42 E+02 Mathematics is enjoyable and stimulating to me
V43 E+04 Once start trying work math puzzle, I find it hard to stop
V44 E+06 am challenged by math problems can't understand immediately
V45 E+05 When ques left unanswer in math class, contin think bout it
V46 E-11 rather have sone give me ans to dif math prob than work out
V47 E+03 When math prob I can't immed solve, stick until I solution
V48 E-12 I do as little work in math as possible
V49 E-10 don't under how some spend so much time on math enjoy it
V50 F+01 father thinks math one mos important subjects I hav studied
V51 F-12 father shown no interest whether I take more math courses
V52 F+02 My father has strongly encoura ed me to do well in math
V53 F-08 My father hates to do math
V54 F-07 father wouldn't encourage me a career involves mathematics
V55 F+03 My father has always been interested in my progress in math
V56 F-09 long as I passd, father hasn't cared how I hav done in math
V57 F- My father says he is not good in mathematics
V58 M- My mother says she is not good in mathematics

V59 M+03 mother has always been interested in my progress in math
V60 M-09 long as passed, mother hasn't cared how I have done in math
V61 M-12 My mother hates to do mathematics
V62 M+05 mother thinks math one most important subject I hav studied
V63 M-10 mother has no interst whether take more math courses or not
V64 M-09 My mother wouldn't encourage me career involves mathematics
V65 M+04 My mother has strongly encouraged me to do well in math
V66 C-11 Most subjects I can handle O.K., but I flubbing up math
V67 C+05 I can get good grades in mathematics
V68 C+03 I am sure that I can learn mathematics
V69 C-10 even though I try, math seems unusually hard for me
V70 C-09 I'm not the type to do well in mathematics
V71 C-07 I'm no good in math
V72 C+06 I have a lot of self-confidence when it comes to math
V73 C+03 DUPLICATE I am sure that I can learn mathematics
V74 C+01 Generally, I have felt secure about attempting math
V75 C-12 Math has been my worst subject