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ABSTRACT

The factorial validity of four of the nine Fennema-Sherman Mathematics Attitudes Scales (FSMASs) was examined for use in measuring fifth graders' interaction with a subject. The following four scales were assessed: (1) the Confidence in Learning Mathematics Scale; (2) the Attitude Toward Success in Mathematics Scale (ATSMS); (3) the Mathematics Anxiety Scale; and (4) the Effectance Motivation in Mathematics Scale (EMMS). Subjects included 59 males and 84 females (aged from 10 years 2 months to 13 years 9 months). Principal factor analysis was conducted to determine whether the 48 items of the four subscales measured the traits suggested by their placement on the scales. Three factors emerged from the analysis. The first was tentatively labelled mathematics anxiety or lack of confidence. The second was made up of items on the ATSMS, and the third included almost all of the items on the EMMS. For this fifth-grade population, two of the FSMASs appear to measure the expected traits, while the other two--confidence in learning mathematics and mathematics anxiety--appear to measure the same trait. (SLD)

Factorial Validity of the Fennema-Sherman Mathematics Attitudes Scales

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Introduction and Background

Considerable concern exists in the mathematical community over attitudes of students toward mathematics as a discipline. Since liking a subject in school is a critical determinant of subsequent study or career interest in the area, much activity is aimed at increasing students' interest in the subject. Griswold (1984) found math achievement and personal responsibility for success to be highly correlated for fourth and fifth graders. Reyes and Stanic (1988) recently postulated a model to explain differences in student achievement. In their model they identified student attitudes as one of the five factors influencing student achievement and school mathematics curricula as one of the factors influencing student attitudes.

The study reported here is a part of a larger effort that explored the impact of the Logo computer language on the problem solving skills, mathematics attitudes, and geometry achievement of fifth graders. The affective variables of mathematics attitudes included confidence in learning mathematics, attitude toward success in mathematics, mathematics anxiety, and effectance motivation in mathematics as measured by four of the Fennema-Sherman Mathematics Attitudes Scales. These four variables were selected due to the researchers' interest in measuring the students' personal interaction with the subject rather than influences of significant others. Furthermore, the demographics of the population and the characteristics of the setting suggested the need to be sensitive to the attention spans of fifth grade students as well as the need to strike a balance between instructional and assessment time. The purpose of this study was to examine the factorial validity of four of the Fennema-Sherman Mathematics Attitudes Scales for use with this population.

Instrument

Fennema and Sherman (1976) developed a set of nine scales designed to "measure some important, domain specific, attitudes which have been hypothesized to be related to the learning of mathematics" (p. 1). The scales include (1) Attitude Toward Success in Mathematics, (2) Mathematics as a Male Domain, (3) Mother, (4) Father, (5) Teacher, (6) Confidence in Learning Mathematics, (7) Mathematics Anxiety, (8) Effectance Motivation in Mathematics, and (9) Mathematics Usefulness.

Each of the scales consists of 12 Likert-type items measured on a five-point scale ranging from 5 (strongly agree) to 1 (strongly disagree). Each scale has equal numbers of positive and negative items. Item development and selection of items for the final version of the scales were described in detail by Fennema and Sherman (1976). The authors reported split-half reliabilities for the scales ranging from .86 to .93. What follow are brief descriptions of the four scales selected for use in the present study.

> The Confidence in Learning Mathematics Scale (C) is intended to measure confidence in one's ability to learn and to perform well on mathematical tasks. The dimension ranges from distinct lack of confidence to definite confidence. The scale is not intended to measure anxiety and/or mental confusion, interest, enjoyment or zest in problem solving. (Fennema & Sherman, 1976, p. 4)

> The Attitude Toward Success in Mathematics Scale (AS) is designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics. They evidence this fear by anticipating negative consequences of success as well as by lack of acceptance or responsibility for the success, e.g., "It was just luck." (Fennema & Sherman, 1976, p. 2)

> The Mathematics Anxiety Scale (A) is intended to measure feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics. The dimension ranges from feeling at ease to those of distinct anxiety. The scale is not intended to measure confidence in or enjoyment of mathematics. (Fennema & Sherman, 1976, p. 4)

> The Effectance Motivation Scale in Mathematics (E) is intended to measure effectance as applied to mathematics. The dimension ranges from

> lack of involvement in mathematics to active enjoyment and seeking of challenge. The scale is not intended to measure interest or enjoyment of mathematics. (Fennema & Sherman, 1976, p. 5)

It is worth noting that Fennema and Sherman found a high correlation (.89) between the Mathematics Anxiety Scale and the Confidence in Learning Mathematics Scale. It was therefore not included in the administration of the final version of the scales in the 1976 report, nor was it used in later studies described by the authors (Fennema & Sherman, 1977, 1978; Sherman, 1979, 1980a, 1980b, 1981, 1982, 1983a, 1983b, Sherman & Fennema, 1977). They did, however, include the final form and data for the Anxiety Scale in their initial report "because some researchers are interested in anxiety as a construct" (p. 8).

A number of investigators have used the Fennema-Sherman Mathematics Attitudes Scales in their research. Rounds and Hendel (1980) used five of the scales to measure attitudes. They also used the Mathematics Anxiety Scale along with another anxiety instrument to measure mathematics anxiety. They found that for a sample of 119 college females, the Mathematics Anxiety Scale correlated more highly with the Confidence in Learning Mathematics Scale (.72) than with the anxiety measure they used.

Betz (1978) and Gayton, Hearns, Breed, and Ozmon (1983) used the Mathematics Anxiety Scale alone to measure anxiety. Elmore and Vasu (1979, 1980, 1986) and Elmore, Broadbooks, Pederson, and Bleyer (1985) used all nine of the Fennema-Sherman Mathematics Attitudes Scales to measure attitudes. Fox (1979), following the recommendation of Fennema and Sherman (1976) to exclude the Mathematics Anxiety Scale, used eight of the scales. Creswell and Houston (1980) used an unknown number of scales. Butler and Austin-Martin (1981) divided their sample into groups based on their scores on the Mathematics

Anxiety Scale, and then measured attitudes using seven of the remaining eight scales (Effectance Motivation Scale excluded). Wittig, Sasse, and Giacomi (1984) administered the Mathematics Anxiety Scale "to measure women's level of confidence with regard to mathematics" (p. 541). Three of these studies were done using junior high and high school students. The remainder were conducted using college students.

Clearly, the scales developed by Fennema and Sherman have been used in the studies mentioned above to measure what researchers have seen as different constructs. In particular, the Mathematics Anxiety Scale has been used to measure both anxiety and confidence; and results from several of the studies have suggested that the Mathematics Anxiety Scale and the Confidence in Learning Mathematics Scale are measuring the same or similar traits.

Only one study was found which examined the factorial validity of the scales. Broadbooks, Elmore, Pedersen, and Bleyer (1981) administered the scale to 1541 students in the seventh and eighth grade, and they performed a principal factor analysis on all 108 items found on the nine scales. Based on their analysis, they reported evidence for eight factors. Two of the scales, Confidence in Learning Mathematics and Mathematics Anxiety were found to load on a single factor. Four items from the Effectance Motivation in Mathematics Scale also loaded on this factor. Correlations between the two scales were .79 for males and .80 for females.

Methods

The four Fennema-Sherman Mathematics Attitudes Scales used in the present study were given to 144 fifth grade students attending public school in a central Alabama college community. They were administered in the school on a pretest-posttest basis by the researcher to measure changes in attitude

following Logo instruction. Students were assured that their responses would not have an effect on their mathematics grades.

The students who participated in the study included 59 males and 84 females (one missing value). Students ranged in age from 10 years 2 months to 13 years 9 months. The average age for the group was 10.99 years (SD=.6223 years). The average score on the Confidence in Learning Mathematics Scale was 45.34 with a standard deviation of 9.402. For the Attitudes Toward Success in Mathematics Scale, the mean was 50.01 and the standard deviation was 7.773. The Mathematics Anxiety Scale had a mean of 42.22 and a standard deviation of 10.322, and the Effectance Motivation in Mathematics Scale mean was 43.42 with a standard deviation of 9.325.

The four subscales that were administered consisted of a total of 48 items (12 on each subscale). Principal factor analysis was conducted to investigate whether the 48 items were measuring the traits suggested by their placement on the four scales or whether, for this population and these items, a different factor pattern emerged. In order to make an initial determination concerning the number of factors to extract and rotate, three criteria were considered. These included Kaiser's criterion (eigenvalues of 1.0 or greater) (Child, 1970), the scree test (Cattell, 1966), and the percent of variance extracted by the factors (Hair, Anderson, Tatham, & Grablowsky, 1979): Principal factor analysis was conducted (squared multiple correlations in diagonals, with iterations), followed by varimax rotation.

Results and Discussion

The scree test suggested the existence of three or four factors, whereas the use of Kaiser's criterion suggested that up to eight factors might be present. In examining the percent of variance extracted by the factors, it

was found that the first five factors together accounted for 70 percent of the variance and each of the factors beyond the fifth factor accounted for less than 5 percent of the variance. Thus, it was decided to begin by rotating from two to six factors. Using factor loadings of .4 or greater as a criterion, simple structure was best approximated by the rotation of three factors. The factor loadings for the items are shown in Table 1.

Table 1.
Varimax-Rotated Factor Loadings for the Three-Factor Solution for Four Subscales of the Fennema-Sherman Mathematics Attitudes Scales

Item	Loadings		
	I	II	III
C 1	64	-08	-17
C 2	-37	28	28
C 3	65	-04	-21
C 4	-40	32	33
C 5	52	-02	-10
C 6	-37	35	23
C 7	53	00	-23
C 8	-34	37	10
C 9	75	-04	-01
C10	-41	20	22
C11	32	-38	-24
C12	-25	24	13
AS 1	04	-49	-11
AS 2	-10	39	27
AS 3	-12	50	20
AS 4	13	-27	-14
AS 5	13	-69	-10
AS 6	-01	71	00
AS 7	12	-64	-05
AS 8	13	-35	-02
AS 9	-07	35	12
AS10	-07	60	23
AS11	24	-59	03
AS12	02	62	07

Table 1 (continued).
Varimax-Rotated Factor Loadings for the Three-Factor Solution for Four Subscales of the Fennema-Sherman Mathematics Attitudes Scales

Item	Loadings		
	I	II	III
A 1	-54	-13	10
A 2	63	-08	-12
A 3	55	-26	-16
A 4	-47	08	-03
A 5	-57	10	06
A 6	58	-28	03
A 7	-43	10	04
A 8	55	-17	-02
A 9	59	-29	02
A10	-18	17	56
A11	70	-19	00
A12	-45	19	11
E 1	38	-28	-15
E 2	-08	21	64
E 3	30	-04	-40
E 4	46	-24	-34
E 5	-45	16	40
E 6	-07	17	44
E 7	15	-17	-68
E 8	-09	10	64
E 9	-02	10	41
E10	17	-05	-54
E11	10	01	27
E12	17	-04	-59
% of Common Variance	44.94	30.31	24.47
% of Total Variance	14.90	10.05	8.21

Note: Decimal points are omitted. Loadings of .40 and above are in bold type.

Factor I

A total of 20 items loaded significantly on the first factor. Of these, 7 were from the Confidence in Learning Mathematics Scale, 11 were from the Mathematics Anxiety Scale, and 2 were from the Effectance Motivation in Mathematics Scale. Another 4 items with factor loadings between .30 and .39

were from the Confidence in Learning Mathematics Scale. For these 4 items, loadings on Factor I were either the highest loadings or were of approximately equal strength as loadings on Factor II.

Present results suggest that the two scales whose items constitute the majority of items on Factor I are measuring the same or similar constructs or traits. Furthermore, it was noted that the positively stated scale items loaded negatively on Factor I and negatively stated items loaded positively. This would suggest that if a name were to be given to the items comprising the factor, the most appropriate label would be Mathematics Anxiety (the name of the scale that contributes over half of the items to Factor I) or Lack of Confidence.

Present findings regarding Factor I are consistent with those of Broadbooks, et al. (1981) concerning the factor structure of the items. The results also corroborate the findings of Fennema and Sherman (1976) that a high correlation existed between the Confidence in Learning Mathematics Scale and the Mathematics Anxiety Scale. (In the present study, the correlation between the two scales was .70.) However, they decided to discontinue using the Mathematics Anxiety Scale. Given the greater strength of that scale on Factor I for the present data, as well as the direction of the loadings, if a choice were made to eliminate a scale rather than combine the two scales, empirical evidence lends somewhat greater support to the elimination of the Confidence in Learning Mathematics Scale, at least for the population from which this sample was taken. Further evidence to support this decision was found in examining the 4-, 5-, and 6-factor solutions. In each instance, the items on the Mathematics Anxiety Scale continued to load strongly on Factor I,

whereas the items from the Confidence in Learning Mathematics Scale began to load on a different factor or on two or more factors.

Factor II

The second factor had significant loadings by nine items. All of the items were from the Attitude Toward Success in Mathematics Scale. In addition, the other three items from the same scale had their highest loadings on this factor. Positive items loaded positively and negative items all loaded negatively. It was interesting to note that 2 of the 3 items that had their highest loadings on Factor II but did not load significantly used negative labels (such as "a grind" and "like me less") as opposed to the other items which used positive labels or phrased positive labels within a negative context (e.g., hiding good grades or feeling conspicuous about winning a prize). The results of the factor analysis provide empirical support for the Attitude Toward Success in Mathematics Scale for the population on which the present sample is based.

Factor III

Similarly, results support the use of the Effectance Motivation in Mathematics Scale. Of the 10 items loading significantly on Factor III, 9 were from this scale. One other item from the same scale had its highest loading on this factor. Again, items that were positively stated on the scale loaded positively on the factor, and negatively stated items loaded negatively. A single item from the Anxiety in Mathematics Scale also loaded significantly on Factor III.

Summary and Conclusions

Three factors emerged from the analysis of the responses of 144 fifth grade students to items on four of the Fennema-Sherman Mathematics Attitude

Scales. The first factor, tentatively labeled Mathematics Anxiety or Lack of Confidence, is composed primarily of items from the Confidence in Learning Mathematics Scale and the Mathematics Anxiety Scale. Factor II is made up of items found on the Attitude Toward Success in Mathematics Scale, and Factor III includes almost all the items from the Effectance Motivation in Mathematics Scale. Present results indicate that, at least for the fifth grade population from which the sample was drawn, two of the Fennema-Sherman Mathematics Attitude Scales are supported by the results of the factor analysis. The other two, Confidence in Learning Mathematics and Mathematics Anxiety, appear to be measuring the same construct. Results suggest either eliminating one of the scales (preferably the Confidence Scale) or combining the two into one scale, possibly called Lack of Confidence. The advantage of using items from both scales to form one new scale would be in the greater reliability achieved in using a larger number of items.

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