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ABSTRACT

The purposes of this study were to: (1) develop a measure of students' attitudes toward mathematics, the Attitudes Toward Mathematics Inventory (ATMI); and (2) find the underlying dimensions of the inventory by testing 262 middle school students at a bilingual college preparatory school. Data were collected from intact 7th and 8th grade mathematics classes. The inventory has 49 items. Students were asked to indicate their degree of agreement with each statement using a Likert-type scale from one to five (strongly disagree to strongly agree). After excluding the nine weakest items, the reliability coefficient alpha was .95. A maximum likelihood factor analysis with a varimax rotation gave three factors: self-confidence; enjoyment of mathematics; and value of mathematics. The reliability coefficients alpha for the scores of the subscales were .94, .92, and .84, respectively. The Psychometric properties were sound, and the Attitudes toward Mathematics Inventory can be recommended for use in the investigation of students' attitudes toward mathematics. (Contains 27 references.) (Author/ASK)

Running head: STUDENTS' ATTITUDES TOWARD MATH

ATTITUDES TOWARD MATHEMATICS INSTRUMENT: AN INVESTIGATION WITH MIDDLE SCHOOL STUDENTS

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ABSTRACT

The purposes of this study were to (a) develop a measure of students' attitudes toward mathematics, the Attitudes Toward Mathematics Inventory (ATMI) and to (b) find the underlying dimensions of the inventory by testing 262 middle school students at a bilingual college preparatory school. Data were collected from intact 7th and 8th grade mathematics classes. The inventory has 49 items. Students were asked to indicate their degree of agreement with each statement using a Likert-type scale from one to five, from strongly disagree to strongly agree. After excluding the nine weakest items, the reliability coefficient α was .95. A maximum likelihood factor analysis with a varimax rotation gave four factors: self-confidence; enjoyment of mathematics; and value of mathematics. The reliability coefficients α for the scores of the subscales were .94, .92, and .84 respectively. The Psychometric properties were sound and the Attitudes Toward Mathematics Inventory can be recommended for use in the investigation of students' attitudes toward mathematics.

Attitudes Toward Mathematics Instrument:

An Investigation with Middle School Students

Much has been written about the decline of mathematics scores on the Scholastic Aptitude Test and a general weakness in mathematics instruction (Goldberg & Harvey, 1983 Dossey, 1992; Dulaney, 1994; The Council of Chief State School Officers, 1998). As more jobs depend on mathematics, concern is mounting about improving mathematics education, teacher preparation, and prompting more students to complete advanced classes. Teachers and parents believe that students' attitudes toward a school subject will affect achievement (Michaels & Forsyth, 1978; Gallagher & DeLisi, 1994; Shashaani, 1995). Clearly, research has shown that attitudes toward mathematics are important in achievement (Dwyer, 1993).

Differences have been found for differential influence of parents (Kenschaft, 1991) and teachers (Dossey, 1992). Attitudes influence success and persistence in the study of mathematics (Chang, 1990; Thorndike-Christ, 1991). Differences in attitudes have been reported for gender, ethnicity, cultural background, and instructional approaches that affect the attitudes of students toward mathematics (Murphy & Ross, 1990; Hollowell & Duch, 1991; Huang, 1993; Leder, 1994). Self-confidence is a good predictor of success in mathematics (Goolsby, 1988; Linn & Hyde, 1989; Randhawa, Beamer, & Lundberg, 1993). Anxiety is directly related to previous school mathematics performance (Hauge, 1991). Terwilliger and Titus (1995) found that positive attitudes toward mathematics are inversely related to math anxiety. Hoffer (1993) reported that attitudes change rapidly and must be studied more intensely if we want to encourage students to pursue studies in these fields. To continue investigations in this area, instruments are needed to support future research.

In this study we attempted to develop an instrument to measure students' attitudes toward mathematics and to investigate the psychometric properties of the instrument. We also attempted to identify the underlying dimensions students' attitudes toward mathematics.

Instrument development

The theoretical construct considered in the development of this instrument was attitudes toward mathematics. *Confidence* (Goolsby, 1988; Linn & Hyde, 1989; Randhawa, Beamer, & Lundberg, 1993), *anxiety* (Hauge, 1991; Terwilliger & Titus, 1995), *value* (Longitudinal Study of American Youth (1990), *enjoyment* (Chang, 1990; Thorndike-Christ, 1991), *motivation* (Chang, 1990; Thorndike-Christ, 1991), and *adults' perspective* (Kenschaft, 1991; Dossey, 1992) have an impact on the attitudes toward mathematics. Thus, the variables under consideration were confidence, anxiety, value, enjoyment, motivation, and adults' perspectives. Table 1 gives sample items of this instrument.

Table 1

Sample items from the *Attitudes Toward Mathematics Inventory*

1. I am always confused in my math class.
2. I feel a sense of insecurity when attempting mathematics.
3. It makes me feel nervous to even think about having to do a mathematics problem.
4. I think studying advanced mathematics is useful.
5. Mathematics is a very worthwhile and necessary subject.
6. Mathematics is dull and boring.
7. I am willing to take more than the required amount of mathematics.

Method

Subjects

The subjects were 262 middle school students from a private, bilingual college preparatory school in Mexico City, Mexico, accredited by The Southern Association of Colleges and Schools. The middle school has approximately 450 students; each grade has approximately 150 students. The students are bilingual, speaking English and Spanish. The school population consists of Mexicans, Mexican-American (born in Mexico with at least one American parent), Americans (children with parents working for international companies of for the United States Embassy), and other nationalities (children with parents working for international companies or different embassies). Most of the students were from high-income families. One hundred thirty seven were boys and 125 subjects were girls from all three grades (6-8) of middle school. The subjects were enrolled in classes conducted by three mathematics middle school teachers. Intact classes were used in the sample.

Of the 137 boys, 2 were in 6th grade, 74 were in 7th grade, and 61 were in 8th grade. Sixty-four percent of the boys were Hispanic, 15% were Euro-American, and 1% was Asian. Eleven boys did not report ethnic background. Of the 125 girls, 71 were in 7th grade and 54 were in 8th grade. Seventy-two percent were Hispanic, 16% were Euro-American, and 5% were Asian. Nine girls did not report ethnic background.

Materials

The Attitudes Toward Mathematics Inventory (ATMI) is a 49-item scale. The items were constructed using a Likert-format scale of five alternatives for the responses with anchors of 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, and 5: strongly agree. Eleven items of this instrument were reversed items. These items were given the appropriate value for the data analysis. The score was the sum of the ratings.

Procedure

The mathematics teachers administered the 49-item inventory to the subjects during their classes. Directions were provided in written form, and students recorded their responses on computer scannable answer sheets.

Results

To estimate internal consistency of the scores, Cronbach α coefficient was calculated. For scores on the 49 items α was .95, indicating a high degree of internal consistency for group analyses. Of the 49 items 40 had item-to-total above .45, with the highest being .80. This suggested that most of the items contributed to the total inventory. The mean and standard deviation of the total score were 178.90 and 27.76 respectively. The standard error of measurement was 6.12.

On the scores on the 49 items the value of α was .95. Although this value indicates high degree of internal consistency, an item deletion process was performed. Items were deleted based on their item-to-total correlation. Nine items had correlations lower than .45. Items were deleted one at a time starting with the one with the lowest item-to-total correlation. After deleting these nine items, α kept a value of .95. The split-half reliability was .83 and the Spearman-Brown reliability was .91.

The revised instrument had a mean of 144.54, a standard deviation of 24.99 and a standard error of measurement of 5.42. All 40 items had item-to-total correlation above

.45, with the highest being .81. This suggested that all items contributed significantly. The test items are homogeneous, tending to measure a single, common trait.

The ATMI responses were subjected to an explanatory factor analysis using maximum likelihood method of extraction and a varimax, orthogonal, rotation. Based on Gorsuch's (1974) recommendation to consider both the Kaiser-Guttman (Kaiser, 1970) criterion of retaining factors with eigenvalues greater than 1.0 and Cattell's (1966) scree test and after examining the items in the factor loading matrices, three factors were retained. The three-factor structure provided the best simple structure fit. The three factors accounted for 46% of the variance. Table 2 shows rank ordered factor loadings, eigenvalues and cumulative percent of variance.

Content validity was built into the construction process by relating the items to the variables under consideration confidence, anxiety, value, enjoyment, motivation, and adults' perspectives. This structure is evidence of construct validity because the data are best explained by the three-factor model supporting different interpretations for students' self-confidence, enjoyment and value of mathematics as underlying dimension of students' attitudes toward mathematics. In Table 3 the top three items of each factor are listed.

In factor analysis, the three-factor solution provided the best simple structure, so three factors were retained. Two pairs of the original variables were combined into two factors. One variable was irrelevant in the factor structure, the one dealing with adults' perspectives. Items in this category were dropped due to their low item-to-total correlation.

Table 2

Exploratory Factor Analysis of the Attitudes Toward Mathematics Inventory: A Three-Factor Solution

Item number	Factor I	Factor II	Factor III	Final Communality Estimates
17	.74	.21	.10	.65
11	.73	.09	.08	.55
10	.71	.07	.03	.51
21	.70	.08	.10	.51
22	.70	.09	.07	.50
16	.69	.16	.08	.51
23	.68	.22	.18	.55
19	.68	.17	.11	.50
12	.66	.31	.24	.59
14	.66	.16	.10	.47
18	.65	.32	.09	.53
24	.60	.33	.09	.47
49	.59	.31	.16	.47
9	.53	.42	.17	.49
42	.49	.34	.19	.39
20	.49	.32	.14	.35
41	.38	.40	.15	.31
30	.40	.74	.24	.76
25	.33	.73	.15	.66
26	.30	.68	.28	.63
27	.25	.66	.24	.56
33	.16	.63	.30	.52
32	.25	.59	.37	.55
35	.23	.56	.30	.46
31	.26	.55	.14	.39
34	.03	.54	.46	.50
15	.49	.50	.17	.51
3	.05	.46	.29	.30
28	.31	.45	.10	.31
29	.20	.43	.28	.31
2	.01	.38	.41	.31
6	.10	.14	.69	.50
5	.09	.07	.66	.45
7	.04	.11	.58	.36
8	.09	.28	.58	.42
1	.16	.27	.55	.40
48	.17	.18	.55	.37
38	.10	.29	.54	.38
4	.17	.26	.44	.29
37	.23	.38	.38	.34
Eigenvalues	14.32	3.97	1.87	
Percent of Variance	43.25	33.84	22.90	

Table 3

Anchor items by factor

Factor	Item content
Self-confidence	Mathematics does not scare me at all.
Self-confidence	Studying mathematics makes me feel nervous.
Self-confidence	My mind goes blank and I am unable to think clearly when working with mathematics.
Enjoyment	I really like mathematics.
Enjoyment	I have usually enjoyed studying mathematics in school.
Enjoyment	Mathematics is dull and boring.
Value	Mathematics is one of the most important subjects for people to study.
Value	Mathematics is important in everyday life.
Value	Mathematics courses will be very helpful no matter what I decide to study.

Having retained three factors, Cronbach α was calculated to estimate internal consistency and reliability of the scores on the subscales. Factor I contains 17 items with a mean of 62.34 (SD = 12.50). Factor I is characterized by students' self-confidence. Items in this factor came from among those generated for anxiety and confidence category of the original list. The scores derived form these items had a Cronbach α of .94.

Factor II contains 14 items with a mean of 45.70 (SD = 11.00) and it is enjoyment of mathematics. Items in this factor came from among those generated for enjoyment and motivation. These items, when scored and summed, produced a Cronbach α of .89.

Factor III contains 9 items with a mean of 36.41 (SD = 5.48). Factor III is characterized by value of mathematics. Items in this factor came from among those generated for enjoyment. The scores on these 9 items produced a Cronbach α of .84.

Split-half reliability and Spearman-Brown reliability were calculated for the total scale and for the subscales, resulting in .83 and .91, respectively, for the Total Scale. Split-half reliability and Spearman-Brown reliability for the scores on the subscales were as follows: Self-confidence, .82 and .90; Enjoyment, .83 and .91; and Value, .70 and .80.

Conclusions

The scores on the revised ATMI indicate a high degree of reliability. The revised instrument has 40 statements using a Likert scoring system, with a coefficient α of .95 and a standard error of measurement of 5.42. Item-to-total correlations reveal good internal consistency. Maximum likelihood factor analysis with a varimax rotation resulted in a three-factor structure as the best simple fit for these items. The three subscales were identified as self-confidence, enjoyment, and value. The 40-item scale developed through factor analysis showed good internal reliability. Split-half reliability for the total scale and the subscales indicates good internal consistency.

There is evidence of content validity. The factor structure of the ATMI revised fits the domain of attitudes' toward mathematics. Anxiety and confidence were reflected in Factor I. Enjoyment and motivation were reflected in Factor II. The value of mathematics was reflected in Factor I. Thus showing evidence of content validity.

As noted above, all items related to adults' perceptions were dropped because of low item-to-total correlations. Although contrary to previous research, this may be characteristic of this particular sample. These subjects all came from high-income families and, perhaps, their regard for adult perspectives may not be typical. Therefore, the instrument should be tested with a more representative sample. It is also possible that adult perspectives are less important than peer perspectives at different developmental ages.

This study was limited to one special population, so it is quite possible that different populations will not yield the same results. Also, the study was conducted with middle school students only and may not be typical of older subjects. The ages and characteristics of the subjects in this study cannot be accepted as a "normative" group for general purposes.

Controls were not applied here for demographic data such as sex, ethnic background, grade level, and mathematics achievement. Undoubtedly, useful information can be obtained that relates sex, ethnic background, grade level, and mathematics achievement to attitudes toward mathematics.

Applications and Implications

Student attitudes are critical in relationship to immediate and long-term goals of teachers, parents and students. While there is widespread concern about the performance of students in mathematics, most attention to the subject has been in the form of higher expectations, testing programs, and revised methodologies, such as the NCTM standards that have provoked considerable controversy. Clearly, there has been insufficient attention to the attitudes of students about mathematics, although there has been much attention to their performance, errors, and test scores. As a political or pedagogical issue, improvement is often debated as simply a matter of methodology. Rather than only concentrating on changing the textbook or the approach, perhaps there are more significant and subtle factors inherent in the attitudes of students themselves that must be more seriously investigated and taken into account.

It is known that there are differential effects of parental and teacher expectations and conduct that effect the attitudes and performance of students. There is also a powerful source of peer pressure that has largely been ignored in attitudinal research. While students may regard certain vocations as high paying and respectable, they may not see themselves as candidates for such careers because of negative stereotyping associated with the peer culture. While much is said about classroom climate, student self-concepts, motivation to learn, and attitudes toward school and specific subject matter, the work has been too general. Students' self-perceived ability is equal to or better as a predictor of failure or success than true ability (Gommage, 1982). A student's attitude is the most important factor in success. We need to learn much more about how attitudes are shaped and changed in order to prevent unnecessary failure in mathematics. If attitudes can be altered and self-assessments of ability improved, significant improvements in performance may be expected as well as plans for long-term career development. While there has been considerable research conducted in the past about self-assessment, most of the literature has been based on instruments that assess general attitudes about school or scholastic achievement.

Opachich, O. & Kadijevich, K. (2000) have summarized research on math and self-concepts with the following major conclusions:

- Mathematics achievement is closely related to self-concepts and attitudes towards mathematics.
- The effects of mathematics attitude on mathematics achievement is mediated by self-efficacy.
- Confidence and self-esteem are linked at higher levels to success in problem solving.
- Confidence of success in a math-related course is a stronger predictor of choosing math majors than either confidence to solve mathematics problems or to perform math-related tasks.
- There are no differences in mathematics achievement by gender, but males have higher mathematics self-concepts and self-perceived mathematics skills than females.

Bandura (1981) argued that judgments of self-efficacy are task specific, making them better predictors of success in a particular domain. Therefore, continued research in the area of attitudes toward math is essential if students are to be understood and motivation is to be changed. The use of a valid and reliable instrument for making determinations about attitudes is a requirement for such research.

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