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ABSTRACT

The factor structure of the responses of girls and boys to the mathematics items on the background questionnaire of the Third International Mathematics and Science Study (TIMSS) was examined in an effort to identify the constructs that underlie the students' attitudes toward the study of mathematics. In addition, the hypothesis of equality of factor structures for boys and girls was tested. The analyses were carried out on data from 3,073 students in grades 3 and 4 and repeated on data from 4,057 students from grades 7 and 8. Results from the study for grades 3 and 4 show that factor structures of girls' and boys' attitudes toward mathematics are quite similar at age 9, and the relationships between these factors and mathematics achievement are similar for the most part. Attitude factors explain only a very small percentage of the observed variation in boys' and girls' mathematics achievement. At age 13, some gender differences in attitudes toward mathematics are apparent, and some gender differences are seen in the percent of variance in responses accounted for by each factor. Attitude explained more of the variation in achievement for the older group. (Contains four tables.) (SLD)

A Comparison of the Factor Structure of Boys' and Girls' Responses to the TIMSS Mathematics Attitude Questionnaire

Abstract for AERA1999

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I. Introduction

The Third International Mathematics and Science Study (TIMSS) was conducted in 1995 in the schools of 45 countries under the sponsorship of the International Association for the Evaluation of Educational Achievement (IEA). TIMSS encompasses three populations of students - the two adjacent grades containing most 9-year-old students (grades 3/4: Population 1), the two adjacent grades containing most 13-year-old students (grades 7/8: Population 2), and students in the final grade of high school (Population 3) (User's Guide for the TIMSS Data Files, November 1997).

Among the various instruments used in this study is the student background questionnaire. This questionnaire includes questions about students' home environment, their academic activities outside of school, their parents' education (only in Population 1), books and other possessions in the home, the importance their mothers, peers and friends place on different aspects of education, and about their experiences in mathematics classes. In addition, the questionnaire solicited responses regarding students' attitudes, beliefs, and opinions related to the study of

mathematics. In general, the structure and the content of the student questionnaire are similar across Populations 1 and 2. However, response options for some questions were reduced from four categories in Population 2 to three categories in Population 1.

II. Objectives

The purpose of this paper is twofold. First, to examine the factor structure of girls and boys' responses to the mathematics items on the TIMSS background questionnaire in an attempt to identify the constructs which underlie their attitudes toward the study of mathematics. The effect of these constructs on students' achievement is also examined. Second, to test the hypothesis of equality of factor structures for boys and girls. This entails the testing of the hypotheses of similar factor patterns, equal units of measurement, and equal accuracy of measurement for the two groups. The foregoing analyses are carried out on grades 3/4 data and repeated on grades 7/8 data in an attempt to examine changes in factor structure of attitudes toward mathematics with age.

III. Rationale/Significance

Gender differences in achievement are too small to explain gender differences in post-secondary educational choices which result in women being under-represented in mathematics related professions. Hence, we examine gender differences in attitudes toward mathematics as a possible explanation for gender differences in

career choice.

Researchers studying gender differences in attitude toward mathematics have traditionally compared total attitude score of boys to that of girls. This approach assumes equal weights for all aspects of attitude for both sexes (i.e. factor loadings of 1). Such assumption may not be accurate. For example, liking math and thinking that math is important may not play equal roles in shaping boys and girls general attitude toward the study of math. These factors may also have differential relative influence on girls' and boys' achievement in mathematics.

The comparison of the factor structure of attitude toward mathematics and of the relative effects of these factors on achievement for Populations 1 and 2 will help our understanding of any changes in girls' and boys' attitudes toward mathematics which might be occurring between the ages of 9 and 13 years. Such knowledge will prove critical in planning intervention strategies to influence these attitudes.

IV. Data

Data used in the present study were collected from students in grades 3/4 and 7/8 in Ontario in 1995. The data file contained sets of complete responses from 3073 students in grades 3/4 (1571 girls and 1502 boys) and 4057 Students in grades 7/8 (2067 girls and 1990 boys).

A total of 24 items from the grade 3/4 questionnaire and 40 items from the grade 7/8 questionnaire are used in this investigation. Some items solicited dichotomous (yes/no) responses, some solicited responses on three, four or five point

ordinal scales.

V. Methods

The following analyses are carried out on grade 3/4 data and repeated on grade 7/8 data:

Analysis I. Exploratory factor analysis with oblimin rotation and Kaiser normalization is used to investigate the factor structure of boys and girls responses to the mathematics items on the background and attitude questionnaire. Factor scores are then used as predictors in a stepwise regression analysis with standardised mathematics score as the outcome variable.

Analysis II. A multi sample LISREL analysis is carried out in order to test the invariance of item functioning for boys and girls. This is done in 3 steps.

Step 1. To test the hypothesis that both boys and girls have the same factor patterns.

Step 2. Given that the two groups have the same factor pattern, to test the hypothesis that the corresponding factor loadings are equal.

Step 3. Given that the above two hypotheses are true, to test the hypothesis that the corresponding latent traits are measured with the same accuracy for both groups. In other words, to test the hypothesis that the standard errors of the factor loadings for the two groups are equal.

VI. Results

Analysis I.

Population 1:

The factor structures of girls' and boys' responses to the mathematics attitudes questions are generally similar in that each is comprised of eight factors which can be summarised as: (1) liking math, (2) importance of doing well in math, (3) role of luck/natural talent/memorization in the success in math, (4) role of hard work in the success in math, (5) self-confidence in math, (6) math homework, (7) group work, (8) teaching/instruction methods.

The above eight factors account for 54.2% of the total variance in girls' responses and 54.5% of the total variance in the boys' responses. The internal structures of the attitude constructs are not the same for boys and girls. These differences are examined in detail in Analysis II.

Correlation of factor scores for girls: The construct 'liking math' is correlated with 'the role of luck/talent/memory', 'importance of doing well in math', 'group work' and 'self-confidence'. The construct 'teaching/instruction methods' is correlated with 'homework', role of luck/talent/memorization', and 'group work'. 'Homework' is correlated with 'group work'.

Correlation of factor scores for boys: 'liking math' is correlated with 'Role of luck/talent/memory', 'importance of doing well in math', and 'self-confidence'. The three constructs 'homework', 'role of luck/talent/memory', and 'group work' are also correlated.

Stepwise linear regression of girls standardized math score on factor scores for

the above eight constructs indicate that students' perception of the 'role of luck/talent/memory' on their success in math is the most significant predictor of achievement followed by their perception of the role of 'hard work/memorization', 'self-confidence', 'liking math', then 'group work'. However, these five factors combined explained only 10.6% of the variation in achievement score. The constructs ''homework', 'importance of doing well in math', and 'teaching/instruction methods' do not have significant effects on girls' achievement. Boys' perception of the 'role of luck/natural talent/memorization in the success in math' is also the most significant predictor of their achievement, followed by their perception of the 'role of hard work/memorization', 'liking math', 'group work', 'teaching/instruction methods', then 'self-confidence'. All six constructs combined explained only 15.9% of the variation in achievement score. The constructs 'homework' and 'importance of doing well in math' do not have significant effects on boys achievement.

Population 2:

Eleven factors are found to explain 53.3% of total variance in the girls' responses and eleven factors are found to explain 54.3% of the total variance in the boys' responses. The factor structures of girls' and boys' attitudes toward mathematics are for the most part similar. The hypothesis if equivalence of factor structure for boys and girls is tested in Analysis II. The factors can be generally described as: (1) liking/doing well in math, (2) importance (to people) of doing well in math and utility of math: these two constructs emerge as one factor for girls and

as two separate factors for boys, (3) role of luck/talent/memorization in the success in math, (4) independent work (for girls only), (5) group work, (6) like/use computers, (7) extra lessons/role of hard work and memorization, (8) tests/calculators/checking each other's homework, (9) math homework, (10) teaching/instruction methods, and (11) textbook/copying notes.

Correlation of factor scores for girls: The construct 'importance of doing well/utility of math' is correlated with 'liking math' , 'textbook/copying notes' and 'extra lessons/hard work and memorization'. The three constructs 'teaching/instruction methods', 'group work', and 'textbook/copying notes' are correlated, and 'group work' is also correlated with 'like/use computers'.

Correlation of factor scores for boys: The construct 'utility of math' is correlated with 'liking math', 'importance of doing well in math', 'teaching/instruction methods', 'homework', and 'role of luck/talent/memorization'. The construct 'liking math' is correlated with 'importance of doing well in math'.

Stepwise linear regression of girls standardized math score on factor scores for the above 11 constructs indicate that 'liking math' is the most significant predictor of girls' achievement followed by their perception of the 'role of luck/talent/memorization in the success in math', 'independent work', 'homework', 'extra lessons/role of hard work and memorization', 'like/use computers', then 'textbook/copying notes'. These seven factors combined accounted for only 24.6% of the variation in achievement score. The constructs 'teaching/instruction methods', 'importance of doing well in math/utility of math', 'group work', and

'tests/calculators/checking each other's homework' do not have significant effects on girls' achievement.

The most significant predictor of boys' achievement is the construct labelled 'extra lessons/role of hard work and memorization' followed by 'liking math', 'role of luck/talent/memorization', 'group work', 'like/use computers', 'textbook/copying notes', 'importance to people', 'test/calculator/checking each other homework', then 'teaching/instruction methods'. These constructs explained 29.7% of the variation in boys' achievement scores. The constructs 'utility of math' and 'homework' do not have significant effects on boys' achievement.

Analysis II:

Analysis II is underway. This analysis will include testing the hypothesis of equivalence of factor structure of boys and girls attitude toward the study of mathematics using multi sample LISREL technique.

VII. Discussion and Recommendation

Analysis I:

Population I:

1. Factor structures of 9 year old boys' and girls' attitude toward the study of math are quite similar.

2. The relationships between these factors and math achievement are similar in the most part. e.g. both boys' and girls' math achievement are highly correlated with

their perception of the role of luck, talent and having good memory, and their perception of the role of hard work and memorization in the success of math.

3. One notable difference in the above is the factor "self-confidence in math". Whereas this factor is a strong predictor of math achievement for girls, it is not as such for boys.

4. Attitude factors as measured by this questionnaire explain a very small percentage of the observed variation in boys' and girls' math achievement. That is, the link between attitude, as measured by this questionnaire, and achievement is weak.

Population II:

1. Unlike factor structure for 9 year olds, at age 13, we are beginning to see some gender differences in attitude toward math.

2. We are seeing some gender differences in the % of variance in responses accounted for by each factor. In addition, a factor about (work independently/gives homework) is found for girls and not for boys. (Importance of math) and (utility of math) are combined in one factor for girls but remain as 2 separate ones for boys.

3. The relationships between attitude factors and math achievement are quite similar for boys and girls except for the factor (extra lessons/role of hard work and memorization). Whereas this factor is the most significant predictor of boys' achievement, it is not as significant a predictor for girls' achievement (check p-values).

4. Attitude factors as measured by this questionnaire explain less than 30% of the

observed variation in boys' and girls' achievement.

Comparison of the two populations (2 age groups):

1. Factor structure is more complex at age 13, whether this is because we can ask more (sophisticated) questions?!

2. Attitude explain more of the variation in achievement for older students.

A full discussion of the findings will include a comparison of the internal structure of the underlying constructs of girls' and boys' attitude toward mathematics, the relative influence of these constructs on achievement, and the change, if any, in both the internal structure of the constructs and their relationships with achievement between the ages of 9 and 13 years. The impact of these findings on educational practices, teaching of mathematics, and on the planning of effective intervention strategies to encourage young women to pursue careers in mathematics and related fields will be presented.

Table 1. Ontario Data, TIMSS 1995

	Number of questions	Number of boys	Number of girls	Total
Population 1 Grades 3/4	24	1502	1571	3073
Population 2 Grades 7/8	40	1990	2067	4057

Table 2. Factor Analysis with Oblimin Rotation and Kaiser Normalization, Grade 3/4

Factor	Significance as predictor of achievement	
	Girls ($R^2 = 10.6\%$)	Boys ($R^2 = 15.9\%$)
Liking math	4	3
Homework	n.s.	n.s.
Role of luck, talent & memory in success in math	1	1
Importance of math	n.s.	n.s.
Group work	5	4
Self-confidence in math	3	6
Role of hard work/memorization	2	2
Teaching/instruction methods	n.s.	5

Above factors accounted for 54% of variance in girls responses and 55% of the variance in boys responses.

Correlations of factor scores:

Girls:

Liking math is significantly correlated with:

* role of luck, talent, memory
* importance of doing well in math
* group work
* self-confidence

Teaching/instruction methods is correlated with:

* homework
* role of luck, talent, memory
* group work

Group work is correlated with homework.

Boys:

Liking math is correlated with:

* role of luck, talent, memory
* importance of doing well in math
* self-confidence in math

Homework, role of luck, talent, memory and group work are all correlated.

Table 3. Factor Analysis with Oblimin Rotation and Kaiser Normalization, Grade 7/8

Girls	Boys
1. Like, do well in math	1. Utility of math
2. Teaching, instruction	2. Teaching, instruction
3. Importance, utility of math	3. Computers: like, use
4. Work independently, homework	4. Extra lessons, hard work, do well, easy
5. Luck, talent, memorization, please parents.	5. Like, do well in math
6. Group work, use calculators	6. Homework
7. Computers: like, use	7. Luck, talent, memorization, please parents
8. Extra lessons, importance, hard work, memorization	8. Group work, use calculators
9. Textbook, copying notes	9. Textbook, copying notes
10. Checking each other homework, tests, calculators	10. Importance to people
11. Homework	11. Test, calculators, check homework
the above 11 factors account for 53% of variance in responses.	The above 11 factors account for 54% of variance in responses.

Table 4. Predictors of Math Achievement, Grade 7/8

Girls (R^2=24.6%)	Boys (R^2=29.7%)
1. Liking math	1. Extra lessons, role of hard work, memorization
2. Role of luck, talent, memorization	2. Liking math
3. Independent work	3. Role of luck, talent, memorization
4. Homework	4. Group work
5. Extra lessons, role of hard work, memorization	5. Computers: like, use
6. Computers: like, use	6. Textbook, copying notes
7. Textbook, copying notes	7. Importance to others
	8. Tests, calculators, checking each other's homework
	9. Teaching, instruction methods

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