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The Effect of Attitude Towards Mathematics and Mathematics Activities on Mathematics Achievement in the TIMSS for the United States and Korea using Structural Equation Modeling

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The purpose of this study is to examine the relationships among attitude towards mathematics, mathematics activity, and mathematics achievement, and compare the relationship between the United States and Korea using the Third International Mathematics and Science Study (TIMSS) database. Since Korea is one of the countries where performance was among the highest and the United States is one of countries where performance was among the middle in mathematics, and many previous researchers reported that attitude towards mathematics and class activities are factors that affect mathematics achievement, the comparison study between two countries would be very important to analyze how factors are affected by country difference. The major research questions are as follows: (1) What constitutes attitude towards mathematics and mathematics activities in the TIMSS database? (2) How do these two variables, attitude towards mathematics and mathematics activities, affect mathematics achievement differently between the United States and Korea? The result indicates that the relationship between the attitude towards mathematics and the mathematics achievement is stronger for Korea than for the United States; however no country difference is found between the mathematics activities and mathematics achievement. According to this study high mathematics achievement is expected when students' attitude towards mathematics is positively high.

I. Introduction and Literature Review

The Third International Mathematics and Science Study (TIMSS) is the largest and most ambitious international comparative study of student achievement to date (Martin, 1996). The TIMSS is a cross-national survey of student achievement in mathematics and science that was conducted at three levels of the educational system in 1995 over 45 countries by the International Association for the Evaluation of Achievement (IEA) (Gonzalez & Smith, 1997; Martin, 1996). Student achievement data were collected in mathematics and science using instruments designed for the TIMSS and translated into the appropriate language.

The TIMSS tested more than half a million students in mathematics and science at three

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separate populations to gain a more in-depth understanding of how various factors contribute to the overall outcomes of schooling. Population 1 is a group of students who enrolled in the two adjacent grades that contained the largest proportion of 9-year-old students at the time of testing (third- and fourth-grade students in most countries). Population 2 is a group of students who enrolled in the two adjacent grades that contained the largest proportion of 13-year-old students at the time of testing (seventh- and eighth-grade students in most countries). Population 3 is a group of students in their final year of secondary education (Gonzalez & Smith, 1997). This study focuses on population 2.

This study is designed to extend current knowledge of attitude towards mathematics, mathematics activities, and mathematics achievement using the Third International Mathematics and Science Study (TIMSS) database. The major research questions are as follows: (1) What constitutes attitude towards mathematics and mathematics activities in the TIMSS database? (2) How do these two variables, attitude towards mathematics and mathematics activities, affect mathematics achievement between the United States and Korea?

One of the purposes of the TIMSS is to examine factors that impact student learning (Martin, 1996). Many previous studies found that the attitude towards mathematics affects mathematics achievement (Odell & Schumacher, 1998; Simich-Dudgeon, 1996; Thorndike-Christ, 1991). Several researchers reported that there were positive or reciprocal relationships between the attitude towards mathematics and mathematics achievement (Gallagher & DeLisi, 1994; Kim & Hocevar, 1998; Ma, 1997; Weinberg, 1995). Few researchers reported that there is no relationship between these two variables (Gilson, 1999).

Odell and Schumacher (1998) conducted an attitude survey of 184 men and 152 women, and reported that attitude, rather than scholastic aptitude test scores, was more useful in predicting grades. Simich-Dudgeon (1996) investigated the relationship between the mathematics attitude of over 32,000 Hispanic and Asian students in the 1992 National Assessment of Educational Progress (NAEP) Mathematics Trial State Assessment, by gender and ethnicity, and by their mathematics performance scores, and found that most of the attitude variables were significant predictors of Hispanic and Asian student mathematics achievement. Thorndike-Christ (1991) examined the relationship between attitude towards mathematics and mathematics achievement, and found that attitude towards mathematics was predictive of final mathematics course grade and was correlated with continuation in advanced mathematics courses once enrollment becomes optional.

Kim and Hocevar (1998) studied racial differences in eighth grade mathematics, and found that attitude towards mathematics was significantly correlated with mathematics achievement. Ma (1997) examined the relationship between the attitude towards mathematics and mathematics achievement for high school seniors, and found that reciprocal relationships existed. Weinberg (1995) did a meta-analysis of the literature on gender difference and student attitude, concluding that there was a correlation between student attitude about science and mathematics and their achievements in science and mathematics. Gallagher and DeLisi (1994) reported a positive relationship between the attitude towards mathematics and performance on standardized mathematics tests.

However, Gilson (1999) investigated the relationship between these two variables using eighth-grade female students attending independent coeducational middle schools, and reported that student attitude towards mathematics scores were not related to mathematics achievement scores or to quantitative ability scores.

Several researchers conducted studies examining the relationship between attitude towards mathematics and mathematics achievement using data from the TIMSS (Gadalla, 1999; Lokan & Greenwood, 2000; Shymansky, Yore, & Anderson, 2000). Shymansky, Yore, and Anderson (2000) examined the changes of student science attitude, awareness and achievement by implementation of interactive-constructivist teaching strategies using data from the TIMSS. Results indicated that there was no significant difference between strategies and attitude, awareness, or achievement. Lokan and Greenwood (2000) analyzed results from the Third International Mathematics and Science Study (TIMSS) for Australia and noted that the importance of student attitude towards mathematics is reinforced by the TIMSS findings. Gadalla (1999) analyzed the TIMSS data and found that attitude factors explain only a very small percentage of the observed variation in mathematics achievement at age 9, but attitude explained more of the variation in mathematics achievement at age 13.

If education is defined as the interaction between teachers and students based on curriculum, classroom activity is one of the most important factors that can affect student achievement. Many previous researchers reported that classroom activities affect mathematics achievement (Aksoy & Link, 2000; Brookhart, 1997; de Jong, Westerhof, & Creemers, 2000; Stegman & Stephens, 2000). Aksoy and Link (2000) studied the relationship between amount of time in learning activities and mathematics achievement, and found that extra time spent on mathematics homework increases test scores. de Jong, Westerhof, and Creemers (2000) studied homework characteristics and effectiveness in mathematics education for secondary school students, and found that amount of homework was the only homework variable related to achievement. Stegman and Stephens (2000) found that high participating students of both sexes outperformed less active counterparts in class rank, mean GPA, and math GPA. Brookhart (1997) examined effects of the classroom assessment environment on mathematics and science achievement, and found that homework affects mathematics achievement.

The US eighth-grade students performed below the international average in mathematics on the TIMSS. In the final year of secondary school (twelfth grade in the United States), the US performance was among the lowest in mathematics, including the most advanced students. This study examines the relationships among attitude towards mathematics, mathematics activity, and mathematics achievement, and compares the relationship between the United States and Korea. Since

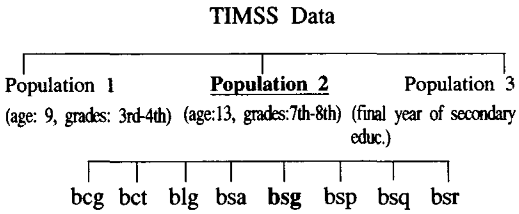
Korea is one of the countries where performance was among the highest in mathematics and many previous researchers reported that attitude towards mathematics and class activities are factors that affect mathematics achievement, the comparison study between two countries would be very important to analyze how factors are affected by country differences.

II. Method

1. Participants

Two student background files, the United States and Korea, in population 2 from the International Mathematics and Science Study (TIMSS) have been selected for this study. The original data file includes 16,800 subjects: 10,973 US subjects and 5,827 Korea subjects. Twenty items concerning attitude towards mathematics and twenty items concerning mathematics activities were extracted from student questionnaire. Subjects who included missing values in attitude towards mathematics and class activities were deleted, and the final data used in the analysis contain 14, 713 subjects: 9,293 US subjects (4,765 females and 4,528 males) and 5,420 Korean subjects (2,428 females and 2,992 males).

[FigureⅡ-1] shows the constitution of the TIMSS data in 1995.



bcg: school background file in population 2

bct: school performance assessment file in population 2

blg: student-teacher linkage file in population 2

bsa: student written assessment in population 2

bsg: student background file in population 2

bsp: student performance assessment file in population 2

bsq: student performance assessment reliability file in population 2

bsr: student written assessment reliability file in population 2

[FigureⅡ-1] Code description of the TIMSS data for both the United States and Korea.

2. Measurements

Attitude towards mathematics scale (ATMS), mathematics activity scale (MAS), and mathematics achievement (MATHACHI) were used in this study. Items of both the ATMS and the MAS and standardized mathematics score for MATHACHI were selected from the student background file in population 2 by the researcher for this study.

Attitude towards Mathematics Scale (ATMS). A sixteen-item scale was developed among twenty items for this study to measure attitude towards mathematics based on item-total statistics and factor analysis. The response format for the ATMS is (1) strongly agree, (2) agree, (3) disagree, and (4) strongly disagree. It was transposed to (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree for subsequent analyses in order to maximize the variability of the total scale scores. Since both countries have the same factor structure of the ATMS, factor analysis was conducted using combined data of the United States and Korea. Its 16 items measure student attitude towards mathematics in terms of underlying factors with significant loadings: (1) math attitude; (2) reason to study math; (3) importance of studying math; and (4) student obedience. This four-factor structure accounts for 43.37% of the variance. Factor I (math attitude) consists of five items: I0012 (enjoy learning math), I0017 (usually do well in math), I0016 (like job involving math), I0014 (math is easy), and I0013 (math is boring). Factor II (reason to study math) consists of five items: I0017 (do well to desired job), I0019 (do well to enter school), I0018 (do well to please parents), I0020 (do well to please myself), and I0015 (math is important in life). Factor III (importance of studying math) consists of four items: I0006 (I think important), I0001 (mother thinks important), I0005 (friends think important), and I0010 (need hard work studying). Factor IV (student obedience) consists of two items: I0004 (students do as teacher says) and I0003 (students orderly and quiet). The internal reliability of the total ATMS of 16 items for combined data between the United States and Korea is Cronbach's α=.8009.

Mathematics Activity Scale (MAS). Twenty items related to mathematics activities were selected from student questionnaire on TIMSS. A nineteen-item scale was developed from twenty items for this study to measure mathematics activities resulting from item-total statistics and factor analysis. The response format for the MAS is (1) most lessons, (2) some lessons, (3) never. It was transposed to (1) never, (2) some lessons, and (3) most lessons for subsequent analyses in order to maximize the variability of the total scale scores. Its 19 items measure mathematics activities for both student and teacher in terms of underlying factors with significant loading: (1) homework and class material; (2) way to teach; (3) way to study; and (4) group study. This four-factor structure accounts for 39.51% of the variance. Factor I (homework and class material) consists of eight items: I0006 (use calculators), I0004 (work from worksheets), I0011 (begin homework in class), I0014 (discuss completed homework), I0003 (have a quiz or test), I0010 (teacher gives homework), I0019 (look at textbook), and I0012 (teacher checks homework). Factor II (way to teach) consists of five items: I0016 (discuss a practical problem), I0018 (ask what students know), I0009 (solve with everyday life things), I0007 (use computer), and I0013 (check each others homework). Factor III (way to study) consists of four items: I0015 (teacher explains rules), I0001 (teacher shows how to do problems), I0020 (solve a related example), and I0002 (copy notes from the board). Factor IV (group study) consists of two items: I0008 (work in pairs or small groups) and I0017 (work in small groups). The internal reliability of the total MAS of 19 items for combined data between the United States and Korea is Cronbach's α=.86.

Mathematics Achievement (MATHACHI). The tests for student mathematics achievement are based on a matrix design whereby blocks of items were distributed across multiple test booklets and the booklets were distributed across students in a country. Each student completed only one test booklet. Test booklets for population 2 consist of eight booklets and each booklet consists of 31 multiple-choice items, 2 short answer items, and 4 extended response items. Because of the difficulty in making any comparisons across the test booklets using only the number of raw score points obtained on a set of items, raw scores were standardized by booklet to provide a simple score which could be used in comparisons across booklets in preliminary analyses. Since one of purposes of this study is to compare the relationships of three variables (attitude toward mathematics, mathematics activity, and mathematics achievement) between the United States and Korea, students' standardized mathematics score was used as mathematics achievement in this study, which has mean of 50 and standard deviation of 10. The means of mathematics achievement are 50.30 for the United States (n = 9,293) and 50.46 for the Korea (n = 5,420). The standard deviations of mathematics achievement are 9.95 for the United States and 9.65 for Korea. The internal reliability of the mathematics achievement test is Cronbach's α=.91 (7th grade) and .92 (8th grade) for Korean and Cronbach's α=.89 (both 7th and 8th grades) for the United States.

III. Result

1. Preliminary Analysis

Factor analysis and Cronbach's alpha were run for both attitude towards mathematics and mathematics activities using combined data file between the United States and Korea. Using this combined data file, the Cronbach's alpha with 16 items on the attitude towards mathematics scale (ATMS) is .80, and the Cronbach's alpha with 19 items on the mathematics activity scale (MAS) is .86. These estimates support subsequent analyses.

Exploratory factor analysis using maximum likelihood with a varimax rotation was conducted both on the ATMS and the MAS using the combined data file. According to the factor analysis, the ATMS consists of four factors that are (1) math attitude, (2) reason to study math, (3) importance of studying math, and (4) student obedience.

The MAS also consists of four factors, which are (1) homework and class material, (2) way to teach, (3) way to study, and (4) group study. The results of this preliminary analysis using the combined data file were used in subsequent analyses using separated data files. The percentages of variance accounted for by the exploratory factor solution are 43.37% for the ATMS and 39.51% for the MAS.

Descriptive statistics and the correlation matrix for the United States and Korea are presented in <Tables Ⅲ-1 and Ⅲ-2>.

〈Table Ⅲ-1〉 Descriptive Statistics and Correlation Matrix for the United States (n=p,293)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
Attitude towards Mathematics Scale (ATMS)											
1. Mathematics attitude	13.56	3.19	1.00								
2. Reason to Study Math	16.94	2.47	.40	1.00							
3. Importance of studying Math	13.63	1.71	.31	.51	1.00						
4. Student Obedience	4.80	1.49	.21	.13	.21	1.00					
Mathematics Activity Scale (MAS)											
5. Homework and Class Material	25.94	3.66	.14	.19	.20	.15	1.00				
6. Way to Teach	11.51	3.19	.20	.19	.13	.16	.33	1.00			
7. Way to Study	13.45	2.25	.17	.23	.24	.21	.44	.38	1.00		
8. Group Study	4.63	1.80	.13	.09	.06	.10	.23	.48	.20	1.00	
Mathematics Achievement (MATHACHI)											
9. Standardized Math Score	50.30	9.95	.19	.03	.06	.05	.07	-.21	.01[a]	-.13	1.00

Note. All of the correlation coefficients are significant at the .01 level except a marked.

〈Table Ⅲ-2〉 Descriptive Statistics and Correlation Matrix for Korea (n = 5,420)

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
Attitude towards Mathematics Scale (ATMS)											
1. Mathematics attitude	11.53	2.50	1.00								
2. Reason to Study Math	14.20	2.47	.24	1.00							
3. Importance of studying Math	13.87	1.78	.21	.33	1.00						
4. Student Obedience	4.85	1.15	.09	.06	.11	1.00					
Mathematics Activity Scale (MAS)											
5. Homework and Class Material	16.64	3.11	.15	.15	.10	.09	1.00				
6. Way to Teach	9.06	2.35	.15	.15	.08	.13	.50	1.00			
7. Way to Study	12.40	2.22	.14	.13	.22	.12	.31	.26	1.00		
8. Group Study	2.81	1.31	.07	.07	.00a	.06	.28	.35	.04	1.00	
Mathematics Achievement (MATHACHI)											
9. Standardized Math Score	50.46	9.65	.36	.08	.26	-.01[a]	-.01[a]	-.07	.19	-.13	1.00

Note. All of the correlation coefficients are significant at the .01 level except a marked.

The means of mathematics achievement are 50.30 for the United States and 50.46 for the Korea. The standard deviations of mathematics achievement are 9.95 for the United States and 9.65 for Korea. These means and standard deviations for the United States and Korea look similar because they have been changed from law scores to standardized scores. Deleting many samples may also influence to decreasing the differences of scores. All of the correlation coefficients for the United States are significant at the .01 level except the correlation coefficient between way of study and standardized math score. All of the correlation coefficients for Korea are statistically significant at the .01 level except the correlation coefficients between student obedience and standardized math score, and homework and class material and standardized math score. While the correlation coefficient between importance of studying math and reason to study math is the highest one (.51) for the United States, the correlation coefficient between way of teach and homework and class material is the highest one (.50) for Korea.

2. Evaluation and Comparison of Structural Equation Models of the United States and Korea

Structural equation modeling (LISREL 8.31) (Jöreskog & Sörbom, 2000) was used to assess the relationships among the ATMS, the MAS, and the mathematics achievement for the United States and Korea based on the result of factor analysis of the combined data file. Model fit determines the degree to which the structural equation model fits the sample data (Schumacker & Lomax, 1996). Model fit criteria commonly used are chi-square (x2), goodness- of-fit index (GFI), adjusted goodness-of-fit index (AGFI), and standardized root-mean-square resi- dual (SRMR) (Jöreskog & Sörbom, 1989).

A significant chi-square (x2) value relative to the degrees of freedom indicates that the observed and estimated matrices differ. Since chi-square (x2) is easily distorted by large sample sizes (Fassinger, 1987), it is considered as a minor model fit criteria in this study. The adjusted goodness-of-fit index (AGFI) adjusts the GFI for degrees of freedom. The standardized root mean square residual (SRMR) is a standardized measure of the residuals resulting from the difference between the sample covariance matrix and the model-implied covariance matrix (Kenny, Lomax, Brabeck, & Fife, 1998). Goodness-of-fit index values, 0 (no fit) to 1 (perfect fit), above .90, AGFI values, 0 (no fit) to 1 (perfect fit), above .90, and SRMR values below .10 often are cited as criteria for acceptable fit (Kenny et al., 1998; Schumacker & Lomax, 1996). Structural equation modeling was conducted to assess the relationships among the ATMS, the MAS, and the mathematics achievement for the United States. Table 3 shows the Maximum- Likelihood (ML) estimates of model 1, 2, and 3 for the United States. Structural equation model- ing consists of latent independent variables, latent dependent variables, and observed variables.

A latent independent variable is any latent variable that is not influenced by any other latent variable in the model, which has variance estimates. A latent dependent variable is any latent variable that is influenced by some other latent variable in the model, which has an equation error variance that indicates the portion of the latent dependent variable that is not explained or predicted by the latent independent and dependent variables in that equation. Observed variables (indicator variables) are variables that are directly observable or measured. Each observed variable has a factor loading estimate and an error variance. Factor loadings are the relationship between the observed variables and latent variables. Path coefficients (or structural coefficients) indicate the strength and direction of the relationships among the latent variables. Error covariance estimate indicates the correlation between the residuals of variables. All the estimates for the United States are statistically significant at .05 level.

In model 1 in <Table Ⅲ-3>, GFI (.94), AGFI (.89), and SRMR (.07) are pretty good when they are compared with model fit criteria. However, chi- square (χ2) of model 1 (χ2 = 2,738.42 with 25 degrees of freedom, p = .000) does not fit well, and the modification indices suggest adding an error covariance between reason to study (REASTUMA) and importance of studying math (IMPSTUMA), model 2 has been run.

〈Table Ⅲ-3〉 Maximum-Likelihood (ML) Estimates for the United States

Estimates	Model 1	Model 2	Model 3
BSMSTDR loading*	1.00	1.00	1.00
ATTITUDE loading*	1.00	1.00	1.00
REASTUMA loading	1.03	.63	.72
IMPSTUMA loading	.65	.37	.45
STUDOBED loading	.24	.23	.26
HMWKCLMA loading*	1.00	1.00	1.00
WAYTEACH loading	1.26	1.35	.81
WAYSTUDY loading	.66	.67	.71
GROPSTUD loading	.51	.55	.27
ATMS → MATHACHI	1.24	1.56	1.41
MAS → MATHACHI	-1.30	-1.78	-.88
ATMS variance	3.03	4.70	3.98
MAS variance	3.57	3.27	4.96
MATHACHI equation error variance	92.73	87.15	93.11
BSMSTDR error variance	.00	.00	.00
ATTITUDE error variance	7.15	5.48	6.19
REASTUMA error variance	2.87	4.24	4.03
IMPSTUMA error variance	1.64	2.26	2.12
STUDOBED error variance	2.04	1.98	1.96
HMWKCLMA error variance	9.82	10.13	8.44
WAYTEACH error variance	4.55	4.19	6.92
WAYSTUD error variance	3.49	3.61	2.60
GROPSTUD error variance	2.31	2.27	2.88
REASTUMA, IMPSTUMA error covariance	-	1.06	.87
WAYTEACH, GROPSTUD error covariance	-	-	1.66
Goodness-of-fit indices:			
x2	2738.42	2338.67	1364.67
df	25	24	23
p value	.00	.00	.00
GFI	.94	.95	.97
AGFI	.89	.90	.94
SRMR	.07	.06	.05

Note. *Observed variables that are fixed. All the estimates are significantly different from zero ($p<.05$). The x2 values for Model 1, Model 2, and Model 3 can be checked for significance using x 2 distribution table.

The error covariance in [Figure Ⅲ-1] between REASTUMA and IMPSTUMA indicates the correlation between the residuals of those variables. In other wards, there is relationship between the variance in REASTUMA and IMPSTUMA that is not explained by ATMS.

The chi-square (x2) of model 2 in Table 3 (x2 = 2,338.67 with 24 degrees of freedom, p = .000) has been improved, but it does not fit well even though other goodness-of-fit indices indicate that data have a good fit.

The modification indices in model 2 suggest adding an error covariance between way of teaching (WAYTEACH) and group study (GROPSTUD), so that model 3 has been run. The error covariance in [Figure Ⅲ-1] between WAYT- EACH and GROPSTUD indicates the correlation between the residuals of those variables. The Model 3 in <Table Ⅲ-3> has been decided as the structural equation model assessing the relations among the ATMS, the MAS, and mathematics achievement. The final Maximum-Likelihood (ML) estimates, model 3, detailed in <Table Ⅲ-3> are used in the structural equation model in Figure 2.

Structural equation modeling was also conducted to assess the relations among the ATMS, the MAS, and the mathematics achievement for Korea. <Table Ⅲ-4> shows the Maximum- Likelihood (ML) estimates of model 1, 2, and 3 for Korea. All the estimates are statistically significant at the .05 level.

In model 1 in <Table Ⅲ-4>, GFI (.96), AGFI (.92), and SRMR (.07) are pretty good. However, the chi-square (x2) of model 1 (x2 = 1,152.95 with 25 degrees of freedom, p = .000) does not fit well, and the modification indices suggest adding an error covariance between reason to study (REASTUMA) and importance of studying math (IMPSTUMA), model 2 has been run. The error covariance in [Figure Ⅲ-1] between REASTUMA and IMPSTUMA indicates the correlation between the residuals of those variables.

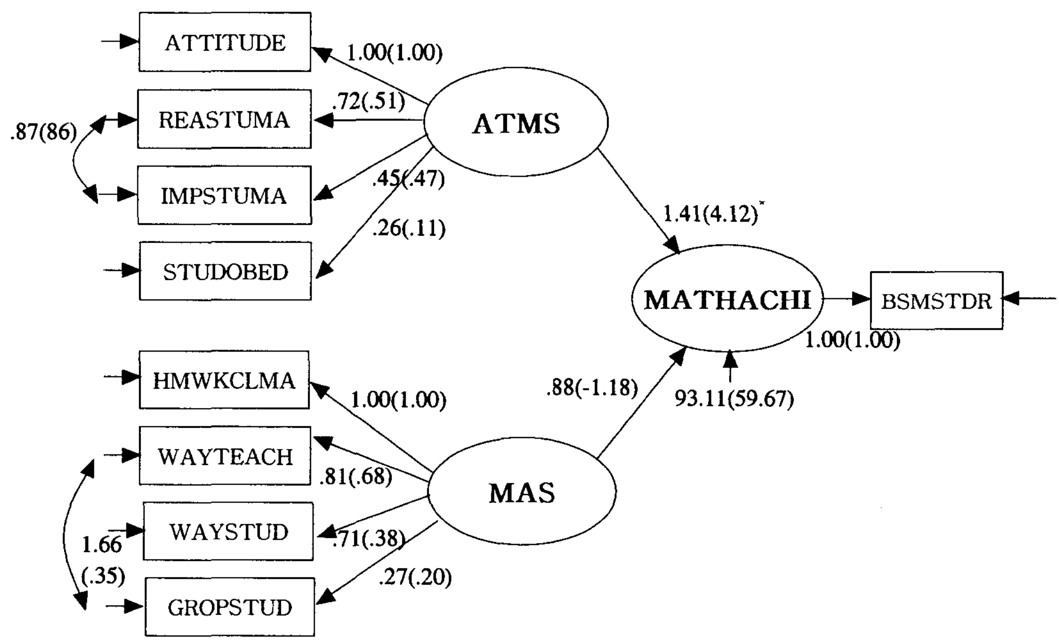
In other words, there is a relationship between the variance in REASTUMA and IMPSTUMA that is not explained by ATMS. The chi-square (x2) of model 2 in <Table Ⅲ-4> (x2 = 969.52 with 24 degrees of freedom, p = .00) has been improved.

〈Table Ⅲ-4〉 Maximum-Likelihood (ML) Estimates for Korea

Estimates	Model 1	Model 2	Model 3
BSMSTDR loading*	1.00	1.00	1.00
ATTITUDE loading*	1.00	1.00	1.00
REASTUMA loading	.70	.51	.51
IMPSTUMA loading	.58	.46	.47
STUDOBED loading	.12	.11	.11
HMWKCLMA loading*	1.00	1.00	1.00
WAYTEACH loading	.81	.82	.68
WAYSTUDY loading	.39	.39	.38
GROPSTUD loading	.26	.26	.20
ATMS → MATHACHI	3.88	4.09	4.12
MAS → MATHACHI	-1.23	-1.37	-1.18
ATMS variance	2.17	2.42	2.38
MAS variance	4.56	4.52	5.34
MATHACHI equation error variance	65.39	58.91	59.67
BSMSTDR error variance	.00	.00	.00
ATTITUDE error variance	4.08	3.83	3.87
REASTUMA error variance	5.04	5.48	5.48
IMPSTUMA error variance	2.43	2.66	2.65
STUDOBED error variance	1.29	1.30	1.30
HMWKCLMA error variance	5.12	5.15	4.34
WAYTEACH error variance	2.52	2.49	3.03
WAYSTUD error variance	4.24	4.26	4.14
GROPSTUD error variance	1.42	1.41	1.51
REASTUMA, IMPSTUMA error covariance	-	.87	.86
WAYTEACH, GROPSTUD error covariance	-	-	.35
Goodness-of-fit indices:			
x2	1152.95	969.52	893.16
df	25	24	23
p value	.00	.00	.00
GFI	.96	.96	.97
AGFI	.92	.93	.93
SRMR	.07	.06	.06

Note. *Observed variables that are fixed. All the estimates are significantly different from zero ($p<.05$). The x2 values for Model 1, Model 2, and Model 3 can be checked for significance using x 2 distribution table.

Since the modification indices in model 2 suggest adding an error covariance between way of teaching (WAYTEACH) and group study (GROPSTUD), model 3 has been run. The error covariance between WAYTEACH and GROP-STUD indicates the correlation between the residuals of those variables. Model 3 in <Table Ⅲ-4> has been decided as the structural equation model assessing the relations among the ATMS, the MAS, and mathematics achievement. The final Maximum-Likelihood (ML) estimates, model 3, detailed in <Table Ⅲ-4> are used in the structural equation model in [Figure Ⅲ-1].



[igure Ⅲ-1] Structural Equation Model Assessing the Relations Among Attitude Towards Mathematics Scale (ATMS), Mathematics Activity Scale (MAS), and Mathematics Achievement (MATHACHI) for the United States and Korea. United States = no parentheses, Korea = in parentheses; All paths are significant (p<.05). Correlated measurement errors: REASTUMA and IMPSTUMA/ WAYTEACH and GROPSTUD. x2 = 1364.67 (893.16) (p=.000), df = 23 (23), GFI = .97 (.97), AGFI = .94 (.93), SRMR = .05 (.06). *Path coefficients differ by country.

The structural equation modeling is a method to build a fit model that explains the best relationship of latent variables based on the goodness-of-fit indices. The model can also be improved by the modification indices. The difference between the model 1 and 2 is including the error covariance between the REASTUMA and the IMPSTUMA in the model 2 based on the modification indices. It means there is relationship between the variance in the REASTUMA and the IMPSTUMA that is not explained by the attitudes toward mathematics. The difference between the model 2 and 3 is containing the error covariance between the WAYTEACH and the GROPSTUD in the model 3 based on the modification indices. The goodness-of-fit indices in the model 3 have been improved comparing to the model 1 and 2. GFI of .96 in the model 1 and 2 was improved to .97 in the model 3. AGFI of .92 in the model 1 was improved to .93 in the model 3. SRMR of .07 in the model 1 was also improved to .06 in the model 3, so that the model 3 is the better fit comparing model 1 and 2.

Figure 2 presents the Maximum-Likelihood (ML) solution for the structural equation model specifying the relation among the ATMS, the MAS, and mathematics achievement (MATH-ACHI) for the United States and Korea.

To analyze the hypothesized structural model, goodness of fit statistics has been assessed. Analysis of the hypothesized structural model with the covariance matrix for the United States resulted in $x2$ (df = 23, n = 9,293) of 1,364.67 ($p = .00$), a goodness-of-fit index (GFI) of .97, an adjusted GFI (AGFI) of .94, and a standardized root mean square residual (SRMR) of .05. Analysis of the hypothesized structural model with the covariance matrix for Korea resulted in $x2$ (df = 23, n = 5,420) of 893.16 ($p = .00$), a goodness-of-fit index (GFI) of .97, an adjusted GFI (AGFI) of .93, and a standardized root mean square residual (SRMR) of .06.

All the indices for both the United States and Korea indicate that data have a reasonable fit. The standardized coefficients representing factor loadings between the indicators and the constructs indicate that each indicator has a positive and statistically significant ($p < .05$) loading on the relevant construct. [Figure Ⅲ-1] shows $x2$, GFI, AGFI, and SRMR for the United States and Korea.

The pathways linking the ATMS with the math achievement and the MAS with the math achievement are statistically significant for both the United States and Korea even though the MAS negatively affects to math achievement. Multiple sample analyses were conducted to determine whether country differences existed among path coefficients.

Structured means multiple sample models revealed that (1) The path from ATMS to MATHACHI was stronger for Korean than for the United States ($p < .05$); and (2) The path from MAS to MATHACHI did not differ by country ($p > .05$).

IV. Conclusion and Discussion

Cronbach's alpha was conducted to test the reliability. Cronbach's alpha is an internal consistency approach to reliability and is considered to represent the mean of all possible split-half coefficients. It is one of the most useful reliability estimates for measures.

The Cronbach's alphas of the ATMS and the MAS are .80 and .86 respectively. These estimates support subsequent analyses.

In this study, an exploratory factor analysis using the combined the US and Korea database with the principal component method of extraction and varimax was appropriate. Based on the eigenvalues greater than one criterion, four factors were retained and accounted for 43.37% of the variance for the ATMS, which are math attitude, reason to study math, importance of studying math, and student obedience. Four factors in the MAS which were retained accounted for 39.51% of the variance, and are homework and class material, way of teach, way of study, and group study.

Structural equation modeling was conducted to analyze the relationships among ATMS, MAS, and mathematics achievement. While multiple regression is used for analyzing the relationships between observed variables and a latent variable, structural equation modeling is used for examining the relationships among latent variables. Since the purpose of this study is examining the relationships among the three latent variables, structural equation modeling is appropriate method.

There is support that both the ATMS and the MAS have an influence on mathematics achievement. The Structural Equation Modeling (SEM) analysis with basic indices that are GFI, AGFI, and SRMR indicate the data have a reasonable fit. Since chi-square (x2) is easily distorted by large sample sizes (Fassinger, 1987) as in the TIMSS, it is considered as a minor fit index.

The pathways linking the ATMS and the MAS with the mathematics achievement are statistically significant for both the United States and Korea.

The ATMS has a positive association with the mathematics achievement for both the United States and Korea, and this result supports many previous studies (Gadalla, 1999; Kim & Hocevar, 1998; Lokan & Greenwood, 2000; Ma, 1997; Odell & Schumacher, 1998; Simich-Dudgeon, 1996; Weinberg, 1995). However, a negative association is found between the MAS and the mathematics achievement for both the United States and Korea. Since many previous studies have been reported that there is positive relationship between class activities and mathematics achievement (Aksoy & Link, 2000; Brookhart, 1997; de Jong et al., 2000), this result does not support the results of previous studies.

The correlation matrix shows that there are negative or very low correlations between the MAS and the mathematics achievement, which means that the mathematics activities effects negatively on mathematics achievement. This may also be a function of the type of mathematics activities used in the study like item 6 (use calculator at class), item 7 (use computer at class), item 8 (group discussion), and item 11 (begin homework at class).

The pathways linking the ATMS with the mathematics achievement and the MAS with the mathematics achievement were tested for country differences and found statistically significant country differences between the ATMS and the mathematics achievement. Korean 7th and 8th grade students out perform the US students in mathematics on the 1995 TIMSS data. Korean students have much higher maximum likelihood estimates relating to mathematics achievement than the US student, which may help to explain why Korean students outperform the US students.

The result indicates that the relationship between the ATMS and the mathematics achievement is stronger for Korea than for the United States; however, no country difference is found between the MAS and the mathematics achievement. The degree of mathematics achievement influenced by the ATMS for Korea is larger than for United States. According to this study, it is obvious that attitude towards mathematics effects on mathematics achievement in both countries. In other words, high mathematics achievement is expected when students attitude towards mathematics is positively high.

Motivating students, explaining the reason to study mathematics, and understanding importance of study mathematics will be helpful to raise mathematics achievement.

A methodological limitation should be considered to evaluate the study. This study only includes two latent variables, student attitudes toward mathematics and mathematics activities as indicators. Mathematics achievement, however, can be influenced from many other variables.

Further research is suggested to examine how other factors like student, home, teacher, and school effect on student academic achievement. Since formal education is the process of interaction between teachers and students using curriculum in the school environment, these factors are critical to student achievement in mathematics.

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Structural Equation Modeling(SEM)을 이용한 미국과 한국의 수학태도와 수학활동이 수학성적에 미치는 효과 비교

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이 연구의 목적은 제3차 국제 수학 과학 연구(Third International Mathematics and Science Study: TIMSS) database를 이용하여 수학태도와 수학활동이 학생들의 수학성적에 미치는 효과를 검정하고 그 결과를 미국과 한국간에 비교하는데 있다. TIMSS의 연구 결과에 따르면 한국 학생들의 수학성적은 연구에 참가한 약 45개국 중에서 거의 최상위권이었지만 미국 학생들의 수학성적은 중위권이었다. 많은 선행연구에 따르면 수학태도와 수학활동은 학생들의 수학성적에 영향을 미치는 요인들이므로 이들 두 요인들이 이들 두 나라에서 어떻게 달리 학생들의 수학성적에 영향을 미치는가를 검정해봄으로써 두 나라간의 수학성적의 차이를 설명할 수 있을 것이다. 이 연구를 위한 주요 연구문제는 첫째, 수학태도와 수학활동을 구성하는 하위 요인들은 무엇인가와 둘째, 수학태도와 수학활동이 미국과 한국에서 어떻게 달리 수학성적에 영향을 미치는가이다. 연구 결과에 의하면 학생들의 수학태도와 수학활동은 수학성적에 영향을 미치는 것으로 나타나 선행연구의 결과와 일치하였다. 수학활동과 수학성적간의 관계는 두 나라에서 유의미한 차이가 없었지만, 수학태도와 수학성적 간의 관계는 한국 학생들이 미국학생들보다 훨씬 강한 것으로 나타났다. 이것은 학생들의 수학태도가 긍정적으로 높을 때 높은 수학성적을 기대할 수 있다는 것을 의미한다.

* **Key Words**: attitude towards 수학태도(mathematics), mathematics 수학활동(activities), mathmatics achievement수학성취도), Structural Equation Modeling (SEM, 구조방정식모형)

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