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A RE-ANALYSIS OF THE TIMSS 1999 MATHEMATICS ASSESSMENT DATA OF THE TURKISH STUDENTS

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Introduction

With the increasing demands for and interests in cross-cultural and cross-lingual comparisons of various student characteristics, international comparative studies such as the Third International Mathematics and Science Study (TIMSS), Progress in International Reading Literacy Study (PIRLS) and the Programme for International Student Assessment (PISA) have drawn the attention of many researchers all around the world. Researchers who are basically interested in science and mathematics achievement at school paid considerable attention to TIMSS for many years since the International Association for the Evaluation of Educational Achievement (IEA) organized this particular project in order to assess students' achievement in line with the school curricula context.

Apart from other subject matter areas, mathematics achievement has drawn special attention from the researchers in various countries because of the relatively low achievement level in this field compared to other subject matter areas. Factors influencing students' mathematics achievement have been the concern of researchers. Some researchers developed models to explain students' mathematics achievement. In these studies, as the predictors of mathematics achievement, antecedent variables, perceived importance of mathematics, and attitudes towards mathematics were studied (Abu Hilal, 2000), as well as self-concepts (Marsh, 1994), family context, learning experiences, self-efficacy, and interest (Ferry, Fouad & Smith, 2000). Investigating this particular issue through the TIMSS data files seems to provide a comprehensive source to analyze mathematics achievement of students from various angles. Besides the publications of the IEA, there

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have been many research projects on the 1995 and 1999 TIMSS-R studies through re-analyses of the national and international data sets (Lassibille & Navarro, 2000). Some compared countries with different levels of performance, some developed models to test previously developed path-analytic models and others examined student, teacher, and school level characteristics (Bos & Kuiper, 1999; Köller, Baumert, Clausen & Hosenfeld, 1999; Lokan & Greenwood, 2000; Papanastasiou, 2000a; Schiller, Khmelkov, & Wang, 2002; Schreiber, 2002; Webster & Fisher, 2000). Even though there have been some minor differences from country to country, in these studies re-analyses of TIMSS data indicated a strong influence of home educational background variables, occupational status, education level of the parents, family size, number of books at home and self efficacy on mathematics achievement (Lokan & Greenwood, 2000; Papanastasiou, 2000b). On the other hand, success attribution, maternal expectations, and friends' expectations had positive impact on attitudes toward mathematics rather than on achievement (Bos & Kuiper, 1999). Variables such as attitudes toward mathematics, student-centered classroom activities, teacher-centered classroom activities, and class discipline, gave unexpectedly weak or no relations with mathematics achievement, whereas non-academic activities such as watching television or engaging in sports indicated a negative relationship (Lokan & Greenwood, 2000; Schreiber, 2002).

As was seen from the literature, the TIMSS data can provide invaluable information for countries and researchers to evaluate their systems from different perspectives, not only in terms of mathematics achievement, but through the use of student and teacher characteristics as well. Turkish students, who first participated in the TIMSS project in 1999, made rather a poor performance. This is not an unexpected result since the national project reports had pointed out Turkish students' difficulties in understanding basic mathematical concepts for many years (Ministry of National Education of Turkey [MONE], 2002). But the TIMSS project, with its comprehensive data, might help educators to understand reasons for this low performance. In this study, a linear structural model will be analyzed to explore factors that are influential in explaining students' achievement in mathematics through the use of the TIMSS Turkish data set. Among the variables investigated, besides the achievement measures, family background characteristics, some student-related affective variables, and instructional practices will be taken into consideration as covered by the TIMSS Student Questionnaire items.

Method

Sample

In this study the target population of TIMSS-R, which is all students enrolled in the upper of the two adjacent grades containing the largest proportion of 13-year-olds at the time of testing, was considered as corresponding to grade level "eight" in Turkey (Martin, Gregory, & Stemler, 2000). The sample design for TIMSS-R was named as a two-stage stratified cluster sample design. The first stage consisted of a sample of schools and the second consisted of a single classroom selected randomly from the target grade in sampled schools (Martin et al., 2000). As a result of this selection process in Turkey, 204 schools with 7841 students were sampled, from governmental schools in 40 cities. The sample included 4540 male and 3301 female students.

Instruments

Responses of students on two TIMSS instruments, the Student Questionnaire and Achievement Test, were used in the present study. The Student Questionnaire sought information on the student's home background characteristics, attitudes and beliefs about mathematics and science, and experiences in mathematics and science classes (Gonzales & Miles, 2001). For the mathematics achievement measure, "plausible variables" were used in the analyses. In the TIMSS-R assessment, all of the students were not required to respond to all of the mathematics items, providing a wide subject matter coverage of the mathematics area while keeping the response burden on individual students to a minimum (Gonzales & Miles, 2001). TIMSS-R achievement measures were described through the use of item response theory (IRT) scaling methods. The IRT scaling used the multiple imputations or "plausible values" method to obtain proficiency scores in mathematics for all students although each student responded to only some of the items. TIMSS generated not one but five plausible values for each student (Gonzales & Miles, 2001). Thus, in this study, all of the five overall mathematics plausible values were used as observed variables to represent the mathematics achievement latent variable in the path analytic model. For the determination of other latent variables based on the Student Questionnaire items, principal component analysis was used as explained in the following sections of the manuscript.

Data Analyses

Data files used in this study were downloaded from the TIMSS International Database (IEA, n.d.). The statistical analyses were conducted through the following steps;

1. Determining the dimensions of the student questionnaire items.
2. Groups of items were chosen to form the latent variables for the path analytic model.
3. Latent variables were evaluated through confirmatory factor analysis.
4. A covariance matrix was constructed among the observed variables for the path analytic model proposed.
5. The fit of the hypothesized path analytic model was tested.

In the study, LISREL 8.30 for Windows (Jöreskog & Sörbom, 1999) with SIMPLIS command language was used to analyze the data. The maximum likelihood estimation method was used in all the LISREL analyses. For the model data fit assessment, Goodness-of-Fit Index (GFI), Adjusted Goodness-of-Fit Index (AGFI), Standardized Root Mean Squared Residual (SRMR), and Root-Mean-Square Error of Approximation (RMSEA) were used in the present study (Browne & Cudeck, 1993; Gerbing & Anderson, 1993; Jöreskog & Sörbom, 1993; Schumacher & Lomax, 1996). The expected values for a good model data fit interpretation are possible if the GFI and AGFI index values are above .90; SRMR and RMSEA index values are below .05.

Dimensions of the Student Questionnaire Items. The dimensionality of 37 items selected from the student questionnaire was first analyzed using principal components analysis. The Scree Test was used to retain and interpret the number of factors in this solution (Stevens, 2002). Seven factors with the eigenvalues of 4.13, 3.05, 2.34, 1.90, 1.67, 1.57, and 1.47 were retained for further analyses.

Table 1: Factor Loadings for Principal Component Factor Analysis

	Factor Loading						
Items	1	2	3	4	5	6	7
I am just not talented	*0.77*	-	-	-	-	-	-
More difficult for me than for others	*0.76*	-	-	-	-	-	-
Like more if not so difficult	*0.72*	-	-	-	-	-	-
Not one of my strengths	*0.72*	-	-	-	-	-	-
Math is boring	*0.62*	-	-0.19	-	-	-	-
I will never really understand it	*0.60*	0.10	-	-	-	-0.11	-0.19
Usually do well in math	*-0.58*	0.15	0.30	-	-	-	0.15
Enjoy learning math	*-0.54*	0.24	0.43	-	-	-	-0.11
Math is an easy subject	*-0.49*	0.33	0.22	-	-	-	-0.27
Like jobs involving math	*-0.42*	0.34	0.29	-	-	-	-0.29
New topic-work in small groups	-	*0.70*	-	-	-	-	-
Work in pairs or small groups	-	*0.59*	-	-	-	-	-
Work on projects	-	*0.58*	-	-	-	-	-
New topic–ask what students know	-	*0.56*	-	-	-	-	0.17
New topic–discuss practical problem	-	*0.55*	-	-	-	-	0.14
Work from worksheets on our own	-0.12	*0.53*	-	-	-	0.12	0.10
New topic–look at textbook	0.11	*0.41*	-	-	-	-	-
Check each others' homework	-	*0.40*	-	-	-	-	0.12
Self importance–do well in math	-	-	*0.75*	-	-	-	0.15
Mother importance–do well in math	-	-	*0.71*	0.10	-	-	0.11
Friends importance–do well in math	-	-	*0.67*	-	-	0.21	0.13
Math is important in life	-0.12	0.14	*0.48*	-	-	-	-
Education level–father	-	-	-	*0.81*	-	-	-
Education level–mother	-	-	-	*0.77*	-	-	-
Number of books in student's home	-	-	-	*0.64*	-	-	-
Outside school-doing jobs at home	-	-	-	-0.30	0.20	0.11	0.13
Outside school-play with friends	-	-	-	-0.12	*0.70*	-	-
Outside school-playing sports	-	-0.18	-	-	*0.63*	-	-0.17
Outside school-watch TV or videos	-	-0.14	-	-	*0.57*	-0.13	0.15
Outside school-play computer games	-	0.11	-	0.23	*0.52*	-	-0.17
Outside school-reading a book	-	0.11	-	-	0.22	0.17	0.16
Orderly and quiet in class	-	0.19	0.14	-	-	*0.75*	-0.14
Do exactly as told in class	-	0.19	0.19	-	-	*0.72*	-
Neglect school work in class	0.20	-	-	-	0.27	*-0.54*	-0.13
Copy notes from the board	-	-	-	-	-	-	*0.59*
New topic-teacher explains rules	-	0.23	0.20	-	-0.20	-	*0.58*
Teacher shows how to do problems	-	0.29	0.10	-	-	-	*0.49*

Note: Loadings below 0.10 were suppressed in the table.

Table 1 presents items grouped as a result of principal component analysis, with their respective factor loadings. Seven factors explained 45% of the total variance in this particular analysis.

Considering the factor structure as indicated in Table 1, latent variables were formed for the path analytic model. In some dimensions all the items were selected, but in others, typical items representing the dimension were selected. In this process two important criteria were used. First the number of observed variables was kept to three as a minimum (Schumacher & Lomax, 1996), second the items with greater factor loadings were primarily preferred. The first factor represents students' perception of failure in mathematics. From this dimension, "I would like mathematics much more if it were not so difficult", "Although I do my best, mathematics is more difficult for me than for many of my classmates", "Nobody can be good in every subject, and I am just not talented in mathematics", "Sometimes, when I do not understand a new topic in mathematics initially, I know that I will never really understand it", and "Mathematics is not one of my strengths" were selected to represent the latent variable labeled "Perception of failure in mathematics". The second factor represented items related to classroom activities. Items such as "We work on mathematics projects in mathematics classes", "We work together in pairs and small groups in mathematics classes", "When we begin a new topic in mathematics, we begin by discussing a practical problem or story related to everyday life", "When we begin a new topic in mathematics, we begin by working together in pairs or small groups on a problem or project", and "When we begin a new topic in mathematics, we begin by having the teacher ask us what we know related to the new topic" were selected to represent the latent variable labeled as "Student-centered classroom activities". The third factor clustered items in line with the importance given to mathematics. Students' perceptions about the importance given to mathematics on "Self importance", "Mother importance" and "Friends importance" were selected to represent the latent variable: "Importance given to mathematics". On the fourth factor "Highest education level – mother", "Highest education level – father", and "Number of books at home" were selected to represent the latent variable: "Home-family background characteristics". In the fifth factor items related to out-of-school activities were clustered. In this particular dimension " On a normal school day I watch TV and video", "On a normal school day I play or talk with friends outside of school", and "On a normal school day I play sports" were chosen for the latent variable named as "Out-of-school activities". In the sixth factor items "In my mathematics class students often neglect their school work", "In my mathematics class students are orderly and quiet during lessons" and "In my mathematics class students do exactly as the teacher says" were chosen to represent the latent variable named as "Classroom climate". Finally in the seventh factor items related to classroom activities were clustered. Items such as "We copy notes from the board", "The teacher shows us how to do mathematics problems", "When we begin a new topic in mathematics, we begin by having the teacher explain the rules and definitions" were used as representing "Teacher-centered classroom activities".

In the next step, with the selected observed variables, a confirmatory factor analysis with seven factors was carried out to assess the fit. The seven-factor model proposed for the confirmatory factor analysis for questionnaire items yielded a 0.96 Goodness of Fit Index (GFI), 0.95 Adjusted Goodness of Fit Index (AGFI), 0.044 Standardized Root Mean Square (SRMR), and 0.042 Root Mean Square (RMSEA) index. These indexes were deemed adequate to treat the respective item groups as distinct latent variables in the path analytic model.

Table 2: LISREL Estimates, Standard Errors for Confirmatory Factor Analysis and Item Means with Response Modes

Latent and Observed Variables	Lambda-x	*SE*	Mean	Response Mode
Out-of-school activities (OUTOFSCH)				
Watch TV or videos	0.31	0.02	2.75	1 (no time) to 5 (more than 5 hours)
Play with friends	0.84	0.04	2.56	
Play sports	0.38	0.02	2.47	
Importance given to mathematics (IMPT)				
Mother importance	0.76	0.01	3.51	1 (strongly disagree) to 4 (strongly agree)
Friend importance	0.72	0.01	3.42	
Self importance	0.84	0.01	3.63	
Home-family background (FAMILY)				
Education level–mother	0.72	0.01	2.07	1 (no school) to 7 (university)
Education level–father	0.84	0.01	2.84	
# of books in home	0.45	0.01	2.42	1 (no books) to 5 (more than 200 books)
Climate in math class (CLIMATE)				
Neglect school work in class	0.22	0.01	2.35*	1 (strongly disagree) to 4 (strongly agree)
Orderly and quiet in class	0.73	0.02	2.81	
Do exactly as told in class	0.81	0.02	2.97	
Perception of failure in math (PERFAIL)				
Like more if not so difficult	0.72	0.01	2.79	1 (strongly disagree) to 4 (strongly agree)
More difficult for me	0.79	0.01	2.63	
I am just not talented	0.80	0.01	2.51	
I will never understand it	0.62	0.01	2.49	
Not one of my strengths	0.73	0.01	2.53	
Teacher-centered activities (TEACACT)				
Teacher shows how to do problems	0.55	0.01	3.34	1 (never) to 4 (almost always)
Copy notes from the board	0.48	0.01	3.57	
New topic–teacher explains	0.69	0.02	3.47	
Student-centered activities (STUACT)				
Work on projects	0.55	0.01	1.86	1 (never) to 4 (almost always)
Work in pairs or small groups	0.59	0.01	1.95	
New topic–discuss practical problem	0.53	0.01	2.21	
New topic–work in small groups	0.79	0.01	1.86	
New topic–ask what students know	0.48	0.01	2.58	

*This item reversed for the analysis.

Table 2 indicates the Lambda-x estimates and standard errors as obtained for each of the observed variables from the confirmatory factor analysis, with their abbreviations, name of the latent variables, response modes, and respective item means.

Lambda-x values, which are the loadings of each observed variable on respective latent variable, indicate reasonable sizes to support the idea of using these latent variables in the proposed path analytic model to explain mathematics achievement of the Turkish students.

The alpha reliability coefficients were .45, .66, .71, .54, .81, .48, and .66 for the latent variables of out-of-school activities, home-family background, importance given to mathematics, classroom climate, perception of failure in mathematics, teacher-centered, and student-centered classroom activities, respectively. Rather low coefficients were obtained for "Out-of-school activities", "Classroom climate" and "Teacher-centered classroom activities" latent variables.

The Model

As was evidenced from the literature review, family background characteristics (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Bos & Kuiper, 1999; White, 1982), importance given to school subjects (Bos & Kuiper, 1999; Papanastasiou, 2000a; Valas, 2001), math ability perceptions, attitudes towards mathematics (Bos & Kuiper, 1999; Lokan & Greenwood, 2000; McLeod, 1992; Utsimi & Mendes, 2000; Webster & Fisher, 2000), classroom and out-of-school activities (Bergin, 1992; Bos & Kuiper, 1999; Holland & Andre, 1987; Marsh, 1992; National Council of Teachers of Mathematics [NCTM], 2000; Webster & Fisher, 2000) might have some impact on the achievement measures of students. Also, family characteristics, classroom climate, teaching-learning activities may affect student attitudes as well as self-efficacy in mathematics (Bos & Kuiper, 1999; Ferry et al., 2000; Papanastasiou, 2000a; Schreiber, 2002). Thus, the model tested in the present study investigated the impact of *Out-of-school activities* (OUTOFSCH), *Home–family background characteristics* (FAMILY), *Importance given to mathematics* (IMPT), *Teacher-centered classroom activities* (TEACACT), *Student-centered classroom activities* (STUACT), *Perception of failure in mathematics* (PERFAIL) and *Classroom climate* (CLIMATE) on *Mathematics achievement* (ACHV). Also impacts of *Out-of-school activities, Home-family background characteristics, Importance given to mathematics, Teacher-centered classroom activities, Student-centered classroom activities,* and *Classroom climate* on *Perception of failure in mathematics* were studied. Finally, *Home-family background characteristics*, *Importance given to mathematics*, *Teacher-centered classroom activities* and *Student-centered classroom activities* were defined as variables affecting *Classroom climate.* Both *Perception of failure in mathematics* and *Classroom climate* were treated as exogenous and endogenous variables in the present study. Figure 1 displays the hypothesized path analytic model to be tested.

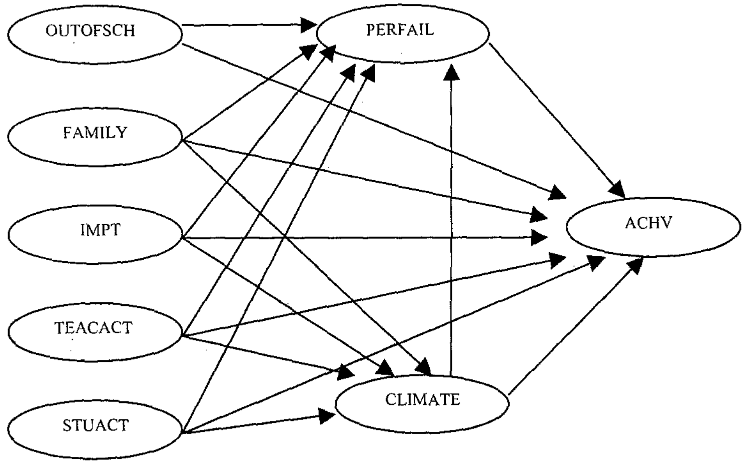

Figure 1: Hypothesized Model

Results

In addition to the model data fit indexes such as GFI, AGFI, SRMR, and RMSEA, the significance of the paths from exogenous to endogenous variables was also considered with respect to the *t*-test results. For the purpose of revising the model data fit, modification indexes were also considered. The paths between *Students-centered classroom activities* and *Perception of failure in mathematics* and; *Perception of failure in mathematics* and *Classroom climate* indicated non-significant *t*-values. The path from *Classroom climate* to *Perception of failure in mathematics* was also found to be non-significant. These paths were deleted from the model. Moreover, as a result of inspecting the modification indexes, three values were considered deviant from the rest. These values are: 392.2, between the observed variables of *More difficult for me than for others* and *Like more if not so difficult*; 144.8, between the observed variables of *Work on projects* and *Teacher shows how to do problems*; and 154.5, between the observed variables of *New topic-discuss practical problem* and *New-topic-teacher explains rule*. Thus, three covariance terms were added into the model between the aforementioned observed variables (Schumacher & Lomax, 1996). Consequently, the model presented in Figure 2 was obtained with the 0.96 GFI, 0.95 AGFI, 0.043 SRMR, and 0.039 RMSEA fit indexes values. These values were deemed adequate to interpret the significant relationships among the latent variables. Table 3 displays Lambda-x estimates, *t*-values and standard errors for mathematics achievement model for Turkey.

Table 3: LISREL Estimates, *t*-values, and Standard Errors for LISREL Model

Latent variables	Observed variables	Lambda-x	*t*	*SE*
PERFAIL	Like more if not so difficult	0.66	60.57	0.01
	More difficult for me	0.75	70.85	0.01
	I am just not talented	0.82	81.15	0.01
	I will never understand it	0.63	57.21	0.01
	Not one of my strengths	0.75	71.67	0.01
ACHV	Plausible value 1	0.90	92.74	0.01
	Plausible value 2	0.89	91.71	0.01
	Plausible value 3	0.90	93.30	0.01
	Plausible value 4	0.90	92.82	0.01
	Plausible value 5	0.90	92.69	0.01
CLIMATE	Neglect school work in class	0.22	16.91	0.01
	Orderly and quiet in class	0.73	49.44	0.02
	Do exactly as told in class	0.81	50.08	0.02
OUTOFSCH	Watch TV or videos	0.31	18.73	0.02
	Playing with friends	0.84	24.32	0.04
	Playing sports	0.38	20.38	0.02
FAMILY	Education level–mother	0.72	57.20	0.01
	Education level–father	0.84	64.49	0.01
	# of books in home	0.45	36.89	0.01
IMPT	Mother importance	0.76	71.62	0.01
	Friend importance	0.72	66.67	0.01
	Self importance	0.84	80.98	0.01
TEACACT	Teacher shows how to do problems	0.55	38.51	0.01
	Copy notes from the board	0.48	34.58	0.01
	New topic–teacher explains	0.67	44.87	0.02
STUACT	Work on projects	0.53	45.02	0.01
	Work in pairs or small groups	0.59	50.10	0.01
	New topic–discuss practical problem	0.52	43.50	0.01
	New topic–work in small groups	0.81	70.69	0.01
	New topic–ask what students know	0.47	38.79	0.01

Table 4 presents the Beta estimates, which are the coefficients among mathematics achievement, perception of failure and classroom climate. The table also presents the Gamma estimates, which are the coefficients among the endogenous and exogenous variables and *t*-values.

Table 4: LISREL Estimates and *t*-values for LISREL Model

Latent variables		Beta	Gamma	*t*
Mathematics achievement & Perception of failure		-0.39	-	-32.32
Mathematics achievement & Climate in math classes		-0.13	-	-10.51
Out-of-school activities & Mathematics achievement		-	-0.03	-2.80
Home family background	& Mathematics achievement	-	0.22	18.81
Importance given to math		-	0.17	13.31
Teacher-centered activities		-	0.05	3.68
Student-centered activities		-	-0.22	-17.21
Out-of-school activities	& Perception of failure	-	0.04	3.11
Home-family background		-	-0.13	-9.29
Importance given to math		-	-0.12	-7.99
Teacher-centered activities		-	-0.07	-4.01
Home-family background	& Climate in math classes	-	-0.07	-4.83
Importance given to math		-	0.28	17.56
Teacher-centered activities		-	-0.04	-2.17
Student-centered activities		-	0.26	16.31

As was seen from Table 4 and Figure 2, which displays the structural model of the mathematics achievement of the Turkish eighth graders, the standardized path coefficients changed between -0.39 and 0.28 in the fitted model. Cohen in 1988 (as cited in Kline, 1998) made some suggestions about interpretations of the absolute magnitudes of path coefficients. According to Cohen standardized path coefficients with absolute values less than 0.10 may indicate a "small" effect; whereas values around 0.30 indicate a "medium" and values above 0.50 indicate a "large" effect, respectively (Kline, 1998). With respect to these criteria, the path coefficient from *Perception of failure in mathematics* to the *Mathematics achievement* indicates a medium effect size. Moreover, the path coefficients from *Home-family background characteristics* and *Student-centered classroom activities* to *Mathematics achievement*, and, path coefficients from *Importance given to mathematics* and *Student-centered activities* to *Classroom climate* could also be considered as medium effect sizes in the model fitted. All the other path coefficients indicated small effects with various magnitudes. The total variance explained in the model was 38% as obtained through R^2 value.

In the model fitted, the greatest effect on mathematics achievement of the students came from *Perception of failure in mathematics*, *Classroom climate*, *Student-centered classroom activities*, *Home-family background characteristics*, and *Importance given to mathematics*. On the other hand, *Out-of-school activities* and *Teacher-centered classroom activities* showed a rather smaller relationship with the achievement measure. When the directions of the relationships were considered, it was observed that *Home–family background characteristics*, *Importance given to mathematics* and *Teacher-centered classroom activities* gave positive relationships with the achievement measures, whereas *Out-of-school activities*, *Student-centered classroom activities*, *Classroom climate* and *Perception of failure in mathematics* indicated rather a negative relationship with mathematics achievement. As was expected, when parents' education level and number of books at home, and importance given to mathematics and frequency of teacher-centered activities increase, students' achievement in mathematics increases as well. On the other hand, as students think that they are unsuccessful in mathematics, they are quiet and orderly in the classroom and neglect schoolwork, they have more student-centered activities in the classroom and they often engage in out-of-school activities, consequently their achievement in TIMSS mathematics measure decreases.

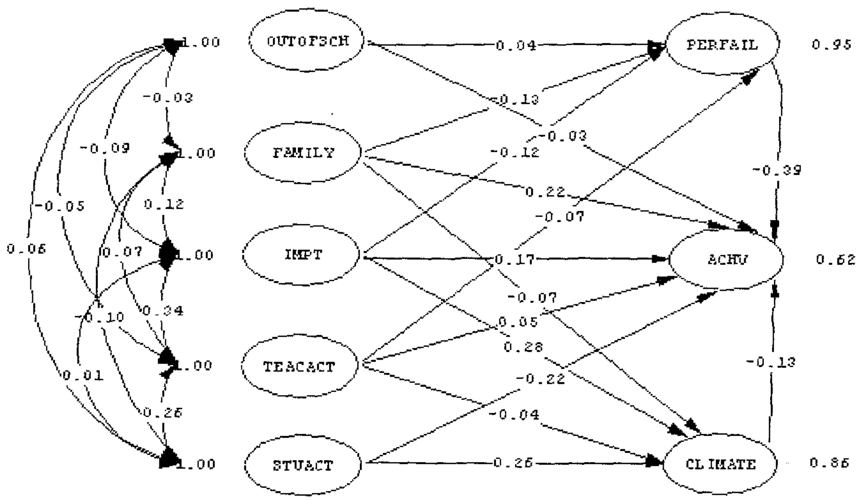

Figure 2: Structural Model of Mathematics Achievement

All the latent exogenous variables except *Out-of-school activities* are negatively related to *Perception of failure in mathematics* such as *Importance given to mathematics*, *Home-family background characteristics*, and *Teacher-centered classroom activities*. There is a remarkable decrease in students' feelings of being unsuccessful in mathematics classes due to the increase in the home educational background characteristics, importance given to mathematics and teacher centered classroom activities.

Similarly, all the exogenous variables except *Importance given to mathematics* and *Student-centered activities* are negatively related to *Classroom climate*, such as *Home family background characteristics* and *Teacher-centered classroom activities*. However, these negative relationships are rather very weak as evidenced by small path coefficients linked to *Home family background characteristics* and *Teacher-centered classroom* *activities* which are -0.06 and -0.08 respectively. Interestingly, as *Student-centered activities* and *Importance given to mathematics* increase, students seem more obedient and orderly in the classroom but neglectful of their schoolwork.

Discussion

This study investigated a linear structural model to explain the relationships among a set of latent variables, constituted through the use of principal component analysis and confirmatory factor analysis. The analysis basically focused on the mathematics achievement of the students as described through the use of plausible variables in the TIMSS project. Beside this particular latent variable, *Perception of failure in mathematics* and *Classroom climate* were also considered as both exogenous and endogenous variables in the model. Thus, in general, factors that are effective in explaining students' mathematics achievement were investigated in the present study. *Perception of failure in mathematics* was found to be the most important latent variable in predicting mathematics achievement. This result is not unexpected when the findings of related studies are considered (Abu-Hilal, 2000; Köller et al.,1999; Shen, 2002; Shen and Pedulla, 2000). Students' feelings about their incompetence in mathematics and their perception of mathematics as a difficult subject deter them from being as successful as their peers. Another strong relation found between *Home-family background characteristics* and the *Mathematics achievements* is supported by the studies conducted by Bos and Kuiper (1999) and Schreiber (2002), where number of books at home was found to be one of the most important indicators of academic success. When the means of the answers to the observed variables of these two respective latent variables are considered, as shown in Table 2, it becomes clear that the Turkish students have a tendency to agree with the statements that reflect their incompetence in mathematics. Also, the means for parental educational level indicated a very low value with a moderate mean observed in the number of books at home. Especially when endorsement rate of this particular item was closely evaluated for the options of *none or very few (0-10 books)* and *enough to fill a shelf (11-25 books)* it was observed that the Turkish students preferred these two alternatives more than the international average whereas less preference was observed in the other alternatives where *enough to fill two bookcases (101-200 books)* and *enough to fill three or more bookcases (more than 200 books)* were mentioned (Mullis, Martin, Gonzales, Gregory, & Smith, 2000).

One of the surprising results of the study is the negative relationship between so called student-centered classroom activities and mathematics achievement in TIMSS tests. The observed variables of this particular latent variable included questions about students' work on projects, work in pairs or small groups and additionally, in line with the new topic, this latent variable also included discussion of practical problems, work in small groups and whether teachers ask what students know in the classroom. As the frequency of these activities increase, students are less likely to be successful in the TIMSS achievement tests. The results seem to be contradictory with respect to the studies conducted by Zabulionis in 1997 (as cited in Lokan & Greenwood, 2000), Lokan and Greenwood (2000), and Bos and Kuiper (1999). However, in the TIMSS survey, similar results were found in Japan (House, 2001) and Italy (Yayan, 2003). Also, as Pelgrum and Plomp (2002) indicated, in high achieving countries, such as Korea, Singapore and Japan, fewer student-centered approaches have been observed based on the TIMSS results. The authors explained this particular finding as an expected outcome where an increase in learner-centered approaches in mathematics may give less time to focus on the reproduction of facts and standard problems, so that the scores on traditional measurements might decline. Actually there could be a couple of similar explanations of this finding in the Turkish sample. First, in the student questionnaire of the TIMSS survey, only the frequencies of these specific activities were sought. However, as in the case of all educational activities, the quality of the instructional processes may be more important than the frequency. In this particular survey, we do not have any information about the quality of the activities cited. For instance, for the project work, no information is available on the teachers' ability to provide feedback to guide the students' progress. Similarly, conducting discussions that foster students' understanding of concepts requires experienced teacher roles. This particular issue needs to be evaluated in line with teacher competencies and abilities to conduct student-centered classroom activities. Another explanation could be due to the outcomes being assessed in the TIMSS mathematics tests, as Pelgrum and Plomp (2002) argued before. As was clearly specified, these tests were designed to assess curricular learning outcomes via a paper and pencil test format. When the outcomes, which are more proper to develop through student-centered activities, are considered, one can claim that it should also emphasize competencies which are beyond the curricular context. Thus, it can be claimed that the content of the tests does not match with the outcomes of student-centered activities per se in this particular project. Additionally, there might be a cultural context to this finding that could be supported by the findings of other research studies. Students could be culturally willing to be receptive in the classroom rather than active in the learning environment; therefore the student-centered activities do not meet their expectations. This premise seems to be supported by other findings in the present study. The positive relationship between *Student-centered classroom activities* and *Classroom climate* implies that as the student-centered activities increase in the classroom, students tend to be more quiet, orderly and neglect the school work. Eventually, in the model, this is reflected as a negative relationship between *Classroom climate* and achievement. More specifically, as student-centered activities increase, it makes classroom environment rather non-participatory, with highly obedient, orderly students who neglect class work, and consequently this leads to a lower achievement in mathematics. This result very strongly supported the claim that student-centered activities do not work as intended in Turkey. On the other hand, another rather weak but positive relation between the achievement measures and the teacher-centered activities can support the same claim that the Turkish students, and teachers as well, are more oriented towards the classical methodologies in the school system rather than independent, open-ended student oriented learning environments. When the means of the observed variables in this latent variable are re-evaluated with reference to Table 2, it was observed that in general student-centered activities were very minimal in the Turkish school system. However, this particular finding needs more in-depth analysis from students' and teachers' perspectives.

Other latent variables such as *Importance given to mathematics* and *Teacher-centered classroom activities* also have a positive impact on students' achievement levels. *Out-of-school activities* gave a negative relationship with the achievement measures. This is a contradictory result with reference to some research findings (Holland & Andre, 1987;

Marsh, 1992) but supported by some others (Bos & Kuiper, 1999; Henggeler, Cohen, Edwards, Summerville, & Ray, 1991; Keith, Reimers, Fehrman, Pottebaum, & Aubey, 1986). However, it is obvious, in the case of Turkish students, that as they spend more time outside curriculum-related activities they are less successful in achievement measures of the TIMSS study. This might be the impact of the very subject-matter oriented and bulky curricular content of the mathematics education at this particular grade level. Compared to their counterparts, Turkish students might be spending more time on curricular activities. At least for mathematics, we can say that the percentages of mathematics topics in the Turkish mathematics curriculum intended to be taught to all or almost all students were above international average for each topic included in the TIMSS 1999 mathematics achievement test as evidenced by the International Report of IEA (Mullis, et al., 2000, p.163).

Home-family background characteristics and *Importance given to mathematics* are both influential in increasing students' confidence in mathematics. It is not surprising to see how improved family background characteristics affects the perception of failure in mathematics measure. There is a positive relationship between *Perception of failure in mathematics* and *Out-of-school activities.* As students watch more television, spend more time with their friends, and engage in sports, they perceive more failure in mathematics-related subjects. This finding could be explained again with the curricular context of the school mathematics in Turkey, which is more subject-matter oriented. Students engaging in non-curricular activities outside the schoolwork might miss topics covered in school, and consequently they feel more helpless in catching up with the curricular content of mathematics classes. If engagement in sports is only considered for this particular latent variable, the results seem to be contradictory with some research findings (Holland & Andre, 1987; Marsh, 1992). This issue needs to be explored in depth for the Turkish students.

Two latent variables contribute more than the others to the *Classroom climate in mathematics class*, namely *Student-centered classroom activities* and *Importance given to mathematics*. The effect of *Student-centered classroom activities* was discussed before in the manuscript. The interesting finding in this particular relationship is the positive impact of *Importance given to mathematics* on *Classroom climate*. Mothers' and peer groups' perceptions about the importance of mathematics might be creating more quiet classroom environments, but as was discussed before this does not necessarily contribute positively to achievement measures of the students. However, both *Home-family background characteristics* and *Teacher-centered classroom activities* create a more disobedient classroom environment. On the contrary, these relations were found to be weak in the present study.

The following conclusions could be drawn from the results of the present study:

Affective measures such as *Perception of failure in mathematics* have a major impact on achievement that could be changed positively through teacher-centered activities and improvements in the home educational background characteristics. Mother, peer group and student perception of mathematics as an important school subject has also very a positive impact on efficacy measures.

Student-centered activities need to be re-structured and evaluated in the Turkish educational system since this survey result did not support the contribution of such activities in enhancing students' achievement. Teachers should be competent enough to carry out these activities effectively in the classroom, which could be quite difficult for those who are culturally more oriented toward classical teaching methodologies.

The findings of the present study clearly indicated that three factors, i.e., home-family background characteristics, what teachers do in the classroom, and students' affective measures are very crucial variables to explain achievement in mathematics. What might be required from educational policy makers in Turkey is to consider these three factors together to enhance the quality of educational practices. A global approach investing in teachers and teaching methodologies, parental education and parent-school cooperation, and students' affective development as well as cognitive development should result in more competent students in the school system.

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