Teacher and Classroom Characteristics and Their Relations to Mathematics Achievement of the Students in the TIMSS

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Abstract

Background: Teacher-related factors such as gender, experience, conceptions related to mathematics, instructional practices have effects with various magnitudes on students' mathematics achievement. Classroom related factors such as class size, class climate and limitations to teaching and their relation to mathematics achievement have also been studied. The TIMSS data provides opportunities to researchers for dealing with these variables simultaneously, thus, makes comparisons in cross-cultural settings.

Aim: To develop a multi-level model that investigate the relation of mathematics teacher and classroom characteristics to students' mathematics achievement in the TIMSS-R data across Turkey and European Union (EU) countries.

Sample: The target population for TIMSS-R was 13-year-old students at the time of testing. Two-stage stratified cluster sample design was used in TIMSS-R. In this study, the data from 10 countries, namely Turkey, Belgium (Flemish), Italy, Netherlands, Czech Republic, Lithuania, Hungary, Slovak Republic, Slovenia and Cyprus were analyzed.

Method: Hierarchical linear modeling (HLM) techniques were employed.

Results: Except the home educational resources, no other variable is significant in all the countries. The variables have different impacts with different magnitudes and directions across the countries except reteaching and clarification, class size, class climate and limitations to teaching. Even though the overall findings obtained in the analyses indicated no consistency in line with significant variables in different countries.

Conclusion: Findings indicated no overall consistency across the countries. Limitations to teaching, class size and class climate are moderately related to mathematics achievement. Re-teaching and clarification and pair work do not contribute to learning in any country. There is no best teaching method in the classroom, when lecture style, guided practice, independent practice are considered. Emphasize on problem solving in the classroom clearly fosters learning in the European Union countries whereas textbook based teaching is effective in Turkey.

Keywords: Hierarchical linear modeling, Mathematics achievement, TIMSS-R

老師和教室特徵及其與學生在TIMSS的數學成就的關係

摘要

*背景：*與老師相關的因素如性別、經驗、與數學有關的構想、教學實踐等對學生的數學成就有不同的影響，相關的教室因素如班級大小、風氣、及對教學的局限性和數學成就的關係也有研究提及。TIMSS的數據提供機會給研究員同時處理這些可變因素，做跨文化的比較。

*目的：*開發一個多層面模式，調查土耳其和歐盟國家的數學教師和教室特徵對學生在TIMSS-R數據的數學成就的關係。

*取樣：*TIMSS-R的目標群眾是在測試之時十三歲的學生，使用兩階段分層的族群抽樣設計。在這項研究中，分析了從土耳其、比利時（佛蘭芒語）、意大利、荷蘭、捷克、立陶宛、匈牙利、斯洛伐克共和国、斯洛文尼亞和塞浦路斯等十個國家的數據。

*方法：*使用階層線性統計模式（HLM）的技巧。

*結果：*在所有國家中，除了各國本身的教育資源外，其他可變量都不顯著。在跨國的研究中，除了重覆施教和闡明、班級大小、風氣、和教學的局限性等外，其他各可變量在不同的層面有不同衝擊和方向。即使分析獲得

的整體研究結果表明沒有一致性，但各國有其不同的顯著因素。

總結：研究表明沒有跨國的一致性結果。教學的局限性、班級大小及風氣與數學成就有些關係，重覆施教和闡明及雙人組合對學習無大幫助，在教室中使用演講、引導學生實踐、獨立實踐等方法各有千秋，沒有最佳的教學方法。歐盟國家強調在教室中使用解決問題教學法明顯地可促進學習，而在土耳其，基於課本的教學是有效的。

關鍵詞：階層線性模式、數學成就、國際數學與科學教育成就研究後續調查

INTRODUCTION

School achievement and factors that are related to learning have been the concern of researchers all around the world since the basic life skills covered in the national curricula are considered as the major requirement for coping with daily life challenges in a literate society. Among different subject matter areas, mathematics is given a special emphasis since many countries suffer from low achievement of students in mathematics related subjects as evidenced by the international studies such as TIMSS (Trends in Mathematics and Science Study) carried out by IEA (The International Association for the Evaluation of Educational Achievement) and PISA (Programme for International Student Assessment) carried out by OECD (Organization for Economic Co-operation and Development).

Among various variables which are related to mathematics achievement of students, the role of teachers in classroom becomes one of the basic issues in educational research since how they interact with students affect learning and conceptual development (Brophy and Good, 1986). The importance given to the effective teaching and its impact on student outcome is evident in various models (Harnischfeger & Wiley, 1975; Simon, 1997; Howie, 2003; Cogan & Schmidt, 1999). Among them, the model of Educational Opportunities which was developed by The Survey of Mathematics and Science Opportunities (SMSO) project team (Cogan & Schmidt, 1999) constitutes a comprehensive base for a successful mathematics teaching in school settings. This study indicated that lessons differed qualitatively from one another in different countries.Since teachers are the key people in this process, their background and beliefs are also important besides some school characteristics. This proposed model constitutes the theoretical base for the TIMSS where teacher and class characteristics are considered as the key aspects for better educational practices. Thus, it is worth investigating how the differences of the patterns observed in the teacher and classroom characteristics are related to mathematics achievement of the students.

In fact, studies generally indicated that teacher-related factors such as gender (Dee, 2006), experience (Greenwald, Hedges and Laine, 1996; Mullis et al, 1997), level of education (Goldhaber and Brewer, 1997; Wayne and Youngs, 2003; Rivkin, Hanushek and Kain, 2005), their conceptions related to mathematics (Thompson, 1992; Romberg and Carpenter, 1986), instructional practices (Koehler and Grouws, 1992), emphasis on problem solving (NCTM, 2000), emphasis on homework (Cooper, Robinson, and Patall, 2006; Jaan, 2006; Braswell et al, 2001), group work (Slavin, 1990), use of textbooks in class (Keeves, 2001), use of calculators (Hembree and Dessart, 1986) have effects with various magnitudes on mathematics achievement of the students.On the other hand, classroom related factors such as class size, class climate and limitations to teaching and their relation to mathematics achievement have also been extensively studied in the literature (Greenwald, Hedges & Laine, 1996; Howie, 2005). The TIMSS data set provides opportunities for researchers in dealing with all of these variables mentioned above simultaneously, thus, makes comparisons of patterns across classrooms with differing characteristics possible in a cross-cultural setting (Philippou and Christou, 1999; Bos and Kuiper, 1999, Schmidt et al, 1999; Keeves, 2001; Stemler, 2001; Papanastasiou, 2002; Schreiber, 2002; Howie, 2003; Kupari, 2003; Fullarton, 2003; Rodriguez, 2004; Van den Broeck, Van Damme and Opdenakker, 2005; Howie, 2005; Yayan and Berberoğlu, 2004).

Actually, the variables which are determinant of school learning have been the concern of educators for many years. For instance, the model of Harnischfeger and Wiley (1975) which is based on the Carroll's Model of school learning includes background characteristics, teaching-learning processes and acquisition as the major sources of variables related to learning (Figure 1). Background includes factors such as courses offered, courses taken, school size, school climate, school resources, socio-economic status, gender. Teaching–learning process includes factors such as in-class and out-of-school activities like answering questions in class, working in groups, or homework. Acquisition is the achievement level for a student in the subject area. As was elaborated in Harnischfeger-Wiley model of school learning, background variables as well as teacher activities are included as major variables of the TIMSS design.

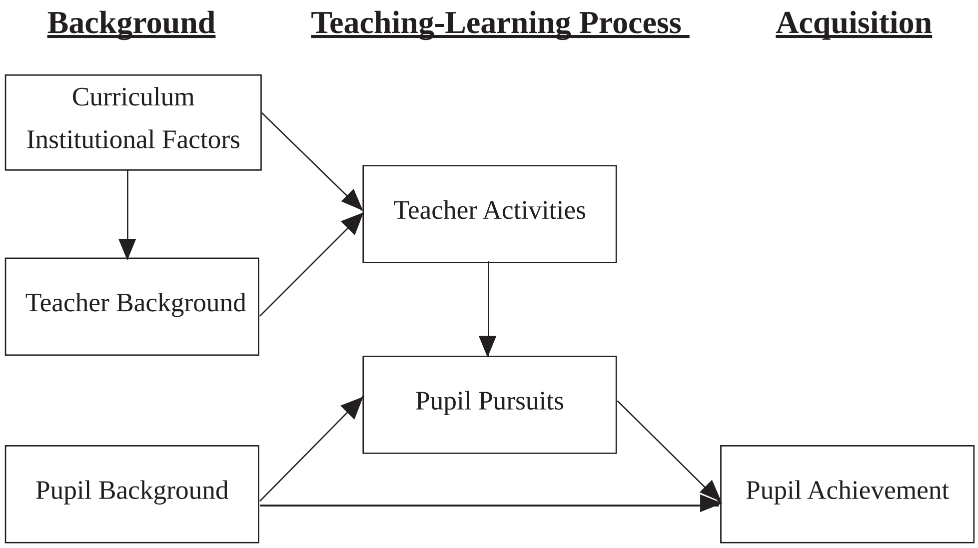

Figure 1. Determinants of Pupil Achievement (Harnischfeger & Wiley, 1975)

Thus, in the present study it is aimed to develop a multi-level model by hierarchical linear modeling (HLM) that investigates the relation of mathematics teacher and classroom characteristics to students' mathematics achievement in the TIMSS-R data across Turkey and European Union (EU) countries.

The model that will be tested through the HLM across different cultures constitutes a base to test the model given in Figure 1 above. The studies that compare teacher characteristics across various countries are limited in the world (Bracey, 2003).When different countries with different educational background participating to the TIMSS are considered, it might be informative to compare the structure of the relationships among the variables for drawing effective policy decisions especially for the countries with relatively lower performance compared to the competing countries, such as Turkey. It is expected that the diversity and similarity among countries with different achievement levels might help developing more effective policy decisions. Thus, the specific research questions of this study were formulated as follows:

1. How much do classes vary in their mean achievement in Turkey and European Union countries?
2. Which factors at the teacher and class level have significant effects on the mathematics achievement of the students across Turkey and European Union countries when home educational resources of student is controlled?
3. How much variance in the mathematics achievement can be explained by the factors related to teacher and class characteristics when "home educational resources" of students is controlled?

METHODS

Population and Sample

The TIMSS-R 1999 data set was used in the present study. The target population for TIMSS-R was all students enrolled in the upper of the two adjacent grades that contain the largest proportion of 13-year-old students at the time of testing. Two-stage stratified cluster sample design was used in the TIMSS-R. The first stage consisted of a sample of schools and the second stage consisted of a single mathematics classroom selected at random from the target grade in sampled schools (Foy & Joncas, 2000).

In this study, the data from 10 countries, namely Turkey, Belgium (Flemish), Italy, Netherlands, Czech Republic, Lithuania, Hungary, Slovak Republic, Slovenia and Cyprus were analyzed. England and Finland were not included in the analyses since the sampling procedure used in England was different from the other nations and "home educational resources" index variable was not available for the Finnish data. The number of classrooms and students included in this study are presented in Table 1.

Table 1 Number of Classrooms and Students in TIMSS-R for Each Country

Country	TIMSS 1999	
	Number of classrooms	**Number of students**
Belgium (Flemish)	279	5259
Czech Republic	142	3453
Cyprus	120	3116
Hungary	147	3183
Italy	180	3328
Lithuania	150	2361
Netherlands	126	2962
Slovak Republic	145	3497
Slovenia	149	3109
Turkey	204	7841
Total	**1642**	**38109**

Instruments

Four background questionnaires, namely curriculum questionnaire, school questionnaire, teacher questionnaire and a student questionnaire were used to gather information at various levels of the educational system in the TIMSS-R (Gonzales & Miles, 2001). In order to determine the mathematics achievement of the students, a mathematics test consisted of 162 items representing a range of mathematics topics and cognitive skills were used.

In this study, data from student background questionnaire, teacher background questionnaire and mathematics test of TIMSS-R were used. There were three criteria in selecting the variables for the model tested. First, theoretical importance of the variables as emphasized in the introduction of this paper, second the amount of missing values in the data file (Raudenbush & Bryk, 2002), and third, the variables should have sufficient variation for a meaningful statistical analysis. The level of education variable was deleted from the Lithuanian data set since it was a uniform variable in this particular country. Detailed information about the variables are explained in the next section.

Variables

Dependent variable

The dependent variable in this study was the mathematics achievement scores of students. Due to the use of rotated booklet every student was not tested on the same items. Therefore, item response theory (IRT) was used to estimate proficiency scores for each individual student. A range or distribution of plausible values for each student's proficiency rather than an individual observed score was estimated. The TIMSS drew five plausible values at random from the conditional distribution of proficiency scores for each student (Gonzales and Miles, 2001). In the HLM analysis, the parameter estimates are based on the average parameter estimates from separate HLM analyses of the plausible values (Raudenbush, Bryk and Congdon, 2000).

Independent variables

Various formats in defining the independent variables were used in the present study, because of the availability of the variables the researchers interested in, and for separating two related constructs measured under the same item root in the TIMSS questionnaires. Thus, (1) the responses given to individual items in the student and teacher questionnaires, (2) index values provided by the IEA and (3) researcher driven variables were used as independent variables in the analyses. The index variables provided by IEA are the combination of the responses given to the items in the questionnaire and they are more reliable than the component questions. However, in some instances when there is no index variable defined in the TIMSS data, individual items or researcher driven variables were constituted for the further analysis. Researcher driven variables were defined by (1) standardizing the summed up raw item scores of the related questionnaire items with a mean of zero and standard deviation of one, and (2) factor analysis driven factor scores. The "class climate" and "limitations to teaching' variables were defined through standardizing the summed up item scores obtained on the related questionnaire items. On the other hand, variables related to teachers' conceptions of mathematics, such as "traditional approaches" and "contemporary approaches" were extracted through principal component analysis, since views for these approaches were presented under the same item root in the TIMSS questionnaire. Detailed information about the independent variables is provided in the following section.

Level 1 Variables

In the level 1 model, student mathematics achievement was estimated as a function of students' "Home Educational Resources". This produced an equation that yields an intercept value for each classroom across all classrooms in countries after adjusting for differences in students' home educational resources. "Home Educational Resources" is an index variable in the database constructed by IEA basing on students' responses to the set of questions such as "Number of books in the home", "Educational aids in the home" and "Father and mother's education". This index variable was coded to three categories as "high", "medium" and "low" by IEA. In this study this variable was recoded as "1" if it was equal to "high" and "0" if it was equal to both "medium" or "low".

Level 2 Variables

The level 2 variables were all related with teacher and class characteristics. Teacher's gender, experience in years, level of education, percentage of time spent on instructional practices, administrative tasks, homework review, lecture style presentation, teacher guided practice, reteaching and clarification of content, independent practice and tests and quizzes, use of textbook and pair-work were item-level responses used from the database. Emphasis given on reasoning/problem solving, emphasis on homework, use of calculators and class size were index variables in the database. On the other hand, class climate, limitations to teaching in mathematics classes were constructed by the researchers by combining the questionnaire items related to these respective variables. After summing up the responses on the related items, the scores were standardized via z score with the mean of 0 and standard deviation of 1. Variables related to beliefs about mathematics and its teaching, namely "contemporary approaches" and "traditional approaches" were constructed by the researchers through factor analysis as explained in the following section. Table 2 summarizes the variables used in the present study.

In general, variables considered in this study were designated into three categories. Teacher characteristics are gender of teacher, experience, level of education and administrative duties. On the other hand, classroom teaching consists of learning activities as lecture style, guided practice, reteaching and clarifications, independent practice, tests and quizzes, emphasis on problem solving, emphasize on homework, pair-work, use of calculators, textbook based teaching, traditional approaches and contemporary approaches. Finally classroom characteristics are the class size, class climate and limitations to teaching.

Table 2 Level 2 Variables Used in Developing Hierarchical Linear Models

Variable	Construction	Item code and the item	Scaling
Gender	Item in MTQ	Are you female or male?	Male:0 Female:1
Experience	Item in MTQ	By the end of this school year, how many years will you have been teaching altogether?	Number of years
Level of education	Item in MTQ	What is the highest level of formal education you have completed?	MA/PHD:1 BA or less:0
Administrative tasks	Item in MTQ	In a typical month of lessons, what percentage of time is spent on administrative tasks?	0-100
Homework review	Item in MTQ	In a typical month of lessons, what percentage of time is spent on homework review?	0-100
Lecture style presentation	Item in MTQ	In a typical month of lessons, what percentage of time is spent on lecture-style presentation by the teacher?	0-100
Teacher-guided practice	Item in MTQ	In a typical month of lessons, what percentage of time is spent on teacher-guided student practice?	0-100
Reteaching and clarification	Item in MTQ	In a typical month of lessons, what percentage of time is spent on re-teaching and clarification?	0-100
Independent practice	Item in MTQ	In a typical month of lessons, what percentage of time is spent on student independent practice?	0-100
Tests and quizzes	Item in MTQ	In a typical month of lessons, what percentage of time is spent on tests and quizzes?	0-100
Textbook based teaching	Item in MTQ	What percentage of your teaching time is based on the textbook?	0-100
Pair-work	Item in MTQ	In mathematics lessons how often do students work in pairs with assistance?	Most/every lesson:1 never or almost never/ some:0
Emphasis given on reasoning/problem solving	Index variable in the database	It was based on numerically recoded responses to the following questions: In your mathematics lessons, how often do you usually ask students to do the following? a) explain reasoning behind an idea; b) represent and analyze relationships using tables, charts, graphs; c) work on problems for which there is not immediately obvious method of solution; e) write equations to represent relationships.	High:1 Medium/ Low:1
Emphasis on homework	Index variable in the database	Index of emphasis on mathematics homework based on teachers' responses to the following questions: a) How often do you usually assign mathematics homework?; b) If you assign mathematics homework, how many minutes of mathematics homework do you usually assign to your students?	High:1 Medium/ Low:1

Variable	Construction	Item code and the item	Scaling
Use of calculators	Index variable in the database	Teachers' reports of students never or hardly ever using calculators in class. Based on teachers' responses that students 'Never or Hardly Ever Use Calculators" to five questions about different classroom activities: How often do students in your mathematics class use calculators for the following activities: a) Checking answers b) Tests and exams c) Routine computation d) Solving complex problems e) Exploring number concepts	1 = Yes (ALL of the questions are marked as never or hardly ever); 0 = No (ANY or NONE of the questions are marked as never or hardly ever).
Class size	Index variable	Teachers' reports of mathematics class size	
Class climate	Researcher driven construct by standardizing and summing up the responses	The items included for this variable were aggragated from the student questionaire data. They were standardised and summed up. The items are; a) In my mathematics class students often neglect their schoolwork. (reverse coded) b) In my mathematics class students are orderly and quiet during lessons. c) In my mathematics class students do exactly as the teacher says.	Sum of the standardized item responses
Limitations to teaching	Researcher driven construct by standardizing and summing up the responses	The items included for this variable were standardised and summed up. The items are; a) Is your teaching limited by students with different academic abilities? b) Is your teaching limited by students from a wide range of backgrounds? c) Is your teaching limited by students with special needs? d) Is your teaching limited by uninterested students? e) Is your teaching limited by disruptive students? f) Is your teaching limited by parents interested in their children's progress? g) Is your teaching limited by parents uninterested in their children's progress? h) Is your teaching limited by shortage of computer hardware? i) Is your teaching limited by shortage of computer software? j) Is your teaching limited by shortage of other instructional equipment for student use? k) Is your teaching limited by shortage of equipment for demonstrations? l) Is your teaching limited by inadequate physical facilities? m) Is your teaching limited by high student/teacher ratio? n) Is your teaching limited by low morale among fellow teachers/administrators? o) Is your teaching limited by low morale among students? p) Is your teaching limited by threats to personal safety or students' safety?	Sum of the standardized item responses

Variable	Construction	Item code and the item	Scaling
Traditional approaches	Researcher driven construct by principal component analysis	a) To be good in mathematics how important is it to remember formulas and procedures? b) To be good in mathematics how important is it to think in a sequential and procedural manner? c) Mathematics is primarily an abstract subject. d) If students have difficulty they should be given more practice by themselves. e) Some students have a natural talent for mathematics and others do not. f) Mathematics should be learned as sets of algorithms that cover all possibilities. g) Basic computational skills are sufficient for teaching primary school mathematics.	Factor scores
Contemporary approaches	Researcher driven construct by principal component analysis	a) To be good in mathematics how important is it to understand mathematical concepts? b) To be good in mathematics how important is it to think creatively? c) To be good in mathematics how important is it to understand real world use? d) To be good in mathematics how important is it to be able to provide reasons to support solutions? e) Mathematics is primarily a practical and structured guide for addressing real situations. f) More than one representation should be used in teaching a mathematics topic. g) A liking for and understanding of students are essential for teaching mathematics.	Factor scores
Mean of Home Educational Resources	Researcher driven construct	Class mean of the Level 1 variable - “Home Educational Resources”	

Note: MTQ is Mathematics Teacher Questionnaire used in TIMSS-R.

Data analysis

Data files used in this study were downloaded from the website of IEA (http://timss.bc.edu/timss1999i/database.html). Hierarchical Linear Modeling (HLM) techniques were employed because of the nested structure of the data and the sampling procedures used in data collection. HLM 6.02 was used in order to build a two-level HLM model which investigated the effects of factors related to teachers’ background, teachers’ instructional practices and class characteristics on the mathematics achievement of the students (Raudenbush and Bryk, 2002). In the analysis, as a first step, one-way ANOVA with random effects model with no predictors at either level 1 or level 2 was built in order to partition the variance within classes and between classes as recommended by Raudenbush and Bryk (2002). The amount of within-class and between-class variance in mathematics achievement gives opportunity to investigate the effect of teacher and class factors on achievement. This analysis also indicates the between-school variances, since there was only one classroom selected from each school. In the second step, “random-intercept model with one level 1 covariate” model (Raudenbush and Bryk, 2002) was built at level 2 to investigate the teacher and class characteristics on mathematics achievement of students. In the analyses, "Home Educational Resources" (HER) was considered as a covariate at level 1 for statistical adjustment. Since the students were not assigned at random to the classes, failure to control for background may bias the estimates of classroom effects. Also, it is known from the literature that "home educational resources" is strongly related to the mathematics achievement of students (Martin et al, 2000). Controlling this particular variable would increase the precision of estimates of classroom effects and the power of hypothesis tests by reducing unexplained level-1 error variance (Raudenbush and Bryk, 2002).

In order to develop models which aim to explain why some schools have higher average achievement than others, there should be a sufficient amount of between –school variability. Ten percent of between-school variability is suggested as minimum variability to consider in other TIMSS secondary analysis (Stemler, 2001; Martin et al, 2000). Thus, in the present study the same amount of variation was used as criterion to explain the between school variability. The models tested in this study are presented below:

Level 1 model

$$\mathbf{Y_{ij} = \beta_{0j} + \beta_{1j}X_{ij} + r_{ij}}$$

i represents the i^{th} student.

j represents the j^{th} school.

Y_{ij} represents the achievement score of i^{th} student in j^{th} school.

B_{0j} represents the intercept in the j^{th} school.

B_{1j} represents the beta coefficient for "Home Educational Resources" in the j^{th} school.

X_{ij} represents the "Home Educational Resources" score of the i^{th} student in the j^{th} school.

r_{ij} is the random error in the j^{th} school.

Level 2 model

$$\mathbf{\beta_{0j} = \gamma_{00} + \gamma_{01} + W_{01j} + \gamma_{02}W_{02j} + ... + \gamma_{0m}W_{0mj} + U_{0j}}$$

$$\mathbf{\beta_{1j} = \gamma_{10} + U_{1j}}$$

B_{0j} represents the intercept in the j^{th} school.

B_{1j} represents the beta coefficient for "Home Educational Resources" in the j^{th} school.

γ_{00} is the average intercept across the level 2 schools.

γ_{10} is the average regression slope across the schools.

u_{0j} and u^{1j} are level 2 random effects.

W_{0pj} is the value of the p^{th} teacher/class level variable in the j^{th} school

In this study, level 1 variable, namely "home educational resources", was centered around its grand mean. So the intercept could be interpreted as the predicted score of an individual whose value for that independent variable was equal to the grand mean. All level 2 variables were also centered around their corresponding grand means as advised by Raudenbush and Bryk (2002).

In HLM analysis, it is important to decide whether the variable is fixed or random at level 1 (Raudenbush and Bryk, 2002). In the present study, firstly a two-level model, which includes HER variable at level 1, was built by considering the variable as random. If the result was significant, it was considered as random. Otherwise it was considered as fixed. As a result of this analysis, it is decided that in the models of Bulgaria, Italy, Czech Republic, Netherlands, Slovenia, Hungary and Lithuania, HER variable at level 1 was considered as fixed.

Using sampling weight in the estimation of population characteristics is essential due to the sample design of TIMSS. In the analysis, total student weight from the database was used at the first level after it was normalized (Willms and Smith, 2005).

RESULTS

One-way ANOVA with random effects provides information about how much variation in the mathematics achievement of students lies within and between classrooms. As explained before, it can be interpreted as the between- and within-school variances due to the selection of only one classroom from each school. The findings are represented in Table 3.

In general, within class variance is generally greater than between class variation. Students within a class are more different from each other than students across different schools in terms of mathematics achievement. However, between-class variance in Belgium (Flemish) and Netherlands are greater than the within class variance. This means that in these particular countries between school differences in terms of mathematics achievement. However, between-class variance in Belgium (Flemish) and Netherlands are greater than the within class variance. This means that in these particular countries between school differences in terms of mathematics achievement is greater than the other countries.

Table 3 Between- and Within-School Variances of Countries

Country	Between-class variance (%)	Within-class variance (%)
Turkey	31	69
Belgium (Flemish)	71	29
Czech Republic	33	67
Hungary	34	66
Italy	36	64
Lithuania	46	54
Netherlands	74	26
Slovak Republic	30	70
Slovenia	13	87
Cyprus*	9	91

* Between class variation is below the criterion value of 10 %

In Table 4, the intercept which provides an estimate of the average mathematics achievement across classes in the country; ß values which were significant at 0.05 level at level 1 and level 2 analyses; reliability of the models for each country and the percentage of the between-school variation explained by the model for each country are presented. When the beta coefficient values are closely evaluated it is observed that, textbook based teaching in Turkey; never or hardly use of calculators in the Netherlands, Belgium and Slovak Republic; emphasis on problem solving in Slovenia; level of education and emphasis on homework in Slovak Republic have high relationship with mathematics achievement. On the other hand, mean of home educational resources has the greatest effect on mathematics achievement in all the countries. Tests and quizzes had positive significant influence on mathematics achievement in Turkey opposite to negative significant effect in Hungary, Lithuania and Netherlands. Pair-work had negative significant effect on mathematics achievement in Slovak Republic and Czech Republic. Teachers with traditional point of view had no effect on student achievement in any country. Among the variables included in the analysis, reteaching and clarification, class size, class climate and limitations to teaching are the variables indicated similar relation with the mathematics achievement, whereas, all the other variables have different directions in terms of their relation to achievement measure.

Table 4 Coefficients in the HLM Models of Countries

Variables \ Countries	**Belgium**	**Slovak Rep.**	**Czech Rep.**	**Hungary**	**Italy**	**Lithuania**	**Netherlands**	**Slovenia**	**Turkey**
INTERCEPT	574.15 (3.33)	541.88 (3.65)	533.27 (4.67)	523.89 (3.78)	477.28 (3.77)	481.35 (3.45)	539.21 (4.73)	530.90 (2.55)	425.87 (4.12)
LEVEL 1 Variable (Covariate)									
Home Educational Resources	11.25 (5.55)	40.29 (5.16)	24.37 (4.36)	37.77 (4.72)	29.68 (4.16)	27.97 (5.02)		50.79 (4.12)	14.37 (4.43)
LEVEL 2 Variables									
Gender			-29.34 (9.98)	14.03 (8.29)			27.27 (14.18)		-14.06 (8.07)
Experience		-0.66 (0.34)					1.65 (0.75)	-0.79 (0.38)	1.56 (0.54)
Level of education		-39.08 (19.89)				NA			
Administrative tasks	-1.91 (0.94)		2.47 (1.47)				-2.98 (1.43)		
Homework review							-3.46 (0.93)		
Lecture style presentation	0.87 (0.34)						-3.76 (1.49)		
Teacher guided practice	0.73 (0.33)			0.33 (0.18)		-0.74 (0.30)			
Reteaching and clarification		-1.83 (0.60)			-2.42 (1.27)		-3.33 (1.05)		-0.88 (0.45)
Independent practice	1.48 (0.44)						-2.95 (1.14)		
Tests and quizzes				-1.13 (0.59)		-1.24 (0.66)	-4.87 (1.85)		1.91 (0.72)
Textbook based teaching									52.30 (17.89)
Pair-work		-24.77 (12.57)	-36.39 (14.83)						
Emphasis given on reasoning/ problem solving			20.72 (9.50)	30.59 (7.76)				26.25 (7.05)	-18.58 (8.82)
Emphasis on homework	19.35 (9.22)	35.20 (15.45)				17.05 (7.64)			
Use of calculators	-36.71 (17.34)	45.73 (11.56)					64.71 (29.34)		
Class size	3.17 (1.10)			1.48 (0.70)	2.02 (0.85)	2.64 (0.57)	4.79 (1.30)		
Class Climate		5.85 (2.57)			8.81 (3.00)				5.75 (3.39)
Limitations to teaching	-2.36 (0.53)				-1.34 (0.50)		-2.41 (0.84)	-0.92 (0.35)	
Traditional approaches									
Contemporary approaches	5.89 (3.55)		-8.82 (4.35)						
Mean of Home Educational Resources	99.34 (25.20)	86.31 (38.17)	163.63 (31.44)	117.47 (17.96)	72.17 (27.31)	118.30 (23.35)	165.76 (46.22)	90.53 (22.40)	58.92 (26.39)
RELIABILITY	**0.93**	**0.81**	**0.72**	**0.69**	**0.83**	**0.73**	**0.94**	**0.58**	**0.86**
EXPLAINED VARIANCE	**63 %**	**62 %**	**69 %**	**46 %**	**63 %**	**74 %**	**43 %**	**44 %**	**45 %**

DISCUSSION

In the present study, the main goal was to develop a two-level hierarchical linear model that investigates the effects of variables related to teacher and class characteristics on mathematics achievement of students. The variance explained was ranged from 43% in Netherlands to 74% in Lithuania. The variations in the variance proportions pointed out that in different countries, variables have different impact on mathematics achievement.

In general, except the home educational resources, no other variable is significant in all the countries. The variables have different impacts with different magnitudes and directions across the countries except reteaching and clarification, class size, class climate and limitations to teaching. Even though the overall findings obtained in the analyses indicated no consistency in line with significant variables in different countries, there are still some important implications that could be drawn for education policy makers. The countries selected in the comparisons are generally above the average performance level, except Turkey. This contrast might be providing some evidence for the low achieving countries to enhance the quality of educational practices.

Teacher Characteristics

With respect to teacher characteristics, the most important variable seems to be the gender of the teacher since in four countries this particular variable is significant. In Turkey and Czech Republic, the classes of male teachers were more successful, in contrast to Hungary and Netherlands. In the literature, the findings related with teacher’s gender are not consistent and the issue is still unresolved. (Dee, 2006) There seems a need to conduct further research and in depth analysis in the related field before concluding that the success in mathematics is related to the gender of the instructor.

However, the different effect of different gender groups on achievement measures across the countries implies that the issue is more related to cultural factors and expectations. As in the case of gender, the experience of teachers in years has also different impacts on learning across countries. In Turkey and Netherlands being experienced in teaching has positive relation with the mathematics achievement. On the contrary, in Slovak Republic and Slovenia the relation is negative. Literature indicates that teachers who have more than five years of experience are more effective (Greenwald, Hedges, and Laine, 1996). Thus, this particular finding of the present study is consistent with this generalization in Turkey and Netherlands since the average years of experience in these countries is around 15. However, it does not explain the relation in Slovenia and Slovak Republic where average years of experience is more than 18 years. It seems that there is a treshold in the years of experience in order to be an effective mathematics teacher in the classroom.

Even though the literature reports positive impacts of teachers’ extra qualifications on student achievement, the findings of the present study did not support this trend (Wayne and Youngs, 2003; Goldhaber and Brewer, 1997). On the other hand, there are also some findings reported that teachers with graduate-level training in a content area indicated no better performance than the teachers having only undergraduate degree (Rivkin, Hanushek, & Kain, 2005). What teachers do in the classroom seems more effective than the degree they earn.

In Belgium (Flemish) and Netherlands, time spent on administrative duties other than teaching had a negative significant effect on student performance. This is not an unexpected result that if teachers are busy with the clerical and administrative tasks, their performance in the classroom declines. Based on their qualitative study Forgazs and Leder (2006) reported that the administrative tasks were more likely to be the cause of stress for the experienced teachers. On the contrary, it is not one of the most important variables to explain achievement in mathematics in the present study because of the low beta coefficients on this particular variable.

Classroom Practices

When the second group of variables namely classroom practices are closely evaluated, similar to the previous group of variables there are differences across the countries. For instance, homework review is not an effective variable in any country, except the negative impact in the Netherlands. On the other hand, emphasize on homework is somehow effective in Belgium, Slovak Republic and Lithuania. However, as a low achieving country, Turkish educational system can not take the advantage of homework in enhancing learning in the mathematics classroom. This is actually not a surprising finding, since in the literature the effect of homework on learning is not clear. In some instances, it is generally ineffective, especially in the early stages of educational years, but as the class level increases, a small amount of homework might be influential to improve learning (Farrow, Tymms & Henderson, 1999). Jaan (2006) reported no relationship between the teachers' emphasize on mathematics homework and students' time for homework with the mathematics scores in the TIMSS across 46 countries. He also stated that students' achievement was significantly lower in countries where homework constitutes the part of mathematics course grades. These findings partly support the finding of the present study, where, in most of the countries either homework review in the classroom and emphasize on home work do not contribute learning.

When teaching methods are concerned, among the various procedures assessed by the TIMSS questionnaire, emphasize on problem solving seems to be the most important strategy to follow among the other techniques such as, lecture, pair work and textbook based teaching. Emphasize on problem solving has positive impact on learning in Czech Republic, Hungary, and Slovenia. It is a surprising result to find out a negative impact of this particular variable in Turkey. The problem seems to lie in the misunderstanding of the meaning of the term 'mathematical problem' among the mathematics teachers. In general, when the mathematics curricula are closely evaluated in Turkey, it is clearly seen that the algorithmic calculations are considered as mathematical problem. The examples of mathematical problems in the textbooks also emphasize algorithmic and routine calculations and they are completely different than the structure of the mathematical problems used in the TIMSS assessment framework. Thus, when teachers in Turkey claim that they emphasize problem solving in the classroom, most probably they are emphasizing algorithmic and routine calculations. As a consequence of this, students' TIMSS score does not improve. Turkey needs to clarify the mathematical problem solving skills in the national curricula with clear examples. However, the use of a single textbook seems effective tool to develop learning of mathematics in Turkey rather than using various materials simultaneously in the mathematics classrooms such as worksheets, mathematical journals and test books. It seems that, teachers could not organize different materials in harmony with each other to develop conceptual change in students. This result is consistent with the literature that textbooks have positive effect in developing countries but no effect have been reported in the more developed countries (Keeves, 2001).

Percentage of time spent on lecture-style teaching had a positive effect on student achievement in Belgium (Flemish), but a negative significant effect in Netherlands.This diverse result is not completely unexpected, since for different groups of students with different needs, diversity in teaching methodologies is a desirable practice in classroom learning (Kyriacou, 1997).

Guided practice followed by independent practice has also different impact on educational outcomes. The percentage of time spent on teacher guided practice in a typical month of mathematics lessons has a positive significant effect in Belgium (Flemish) and Hungary, but a negative significant effect in Lithuania. Similarly, the percentage of time spent on student independent practice in Belgium (Flemish) has a positive significant effect on student achievement, but a negative significant effect in Netherlands. Guided practice and independent practice are two important parts of an effective lesson (Rosenshine and Stevens, 1986). The different findings among the countries imply the practical differences in the school settings across the countries. With respect to teaching methodologies, only in Belgium (Flemish) there is a consistent pattern in the findings of the present study where the teacher-guided and student-independent practice had all positive significant effect on students' learning. Belgium (Flemish) is one of the most successful countries in the TIMSS-R. When significant positive impacts of lecture style, guided practice, independent practice, emphasize on homework and contemporary approach are considered together, it could be said that in this particular country, classroom practices are all consistent and in harmony with each other promoting student learning.

In Turkey, Slovak Republic, Italy and Netherlands, the percentage of time spent on re-teaching and clarification of content in a typical month of mathematics lessons has negative significant effect on mathematics achievement of students. This may be due to the reason that low-achieving students need re-teaching and clarification of content more than the high-achieving students. Continuous re-teaching might be developing a negative perception in students about their academic skills, and consequently the lack of positive academic self concept might be lowering down the achievement scores. Grouping students with respect to their academic background for re-teaching is a practice like ability grouping. When there is ability grouping in the classroom, students in the top tracks gain nothing and other students suffer from loss of academic ground, self-esteem, and ambition (Oakes as cited in Kulik, 1993). The ability grouping was abandoned in the educational practices in many countries because of the undesirable outcomes. However, the re-teaching practice seems bringing ability grouping into the school system again.

The percentage of time spent on tests and quizzes in a typical month of mathematics lessons has a positive significant effect in Turkey and has a negative significant effect in Hungary, Lithuania and Netherlands. In Turkey, the education system is highly test-oriented. This might be the reason of having different results in Turkey compared to other European Union countries.

Small group instruction where two or more students work together on a task is supported by most of the teachers and researchers. In the literature, there are studies indicating that using small groups within mathematics classes in various types of different tasks has positive effect on student learning (Davidson, 1985; Slavin, 1990). However, in the present study in Slovak and Czech Republic the effect is negative. A similar result was also reported in the literature for Cyprus, Hong-Kong, Turkey and the USA where more emphasize on group work brought lower students achievement (Papanastasiou, 2002; Yayan & Berberoğlu, 2004; Kalender & Berberoğlu, 2008). This could be explained in line with the teachers' qualifications where, small group and pair works require a competent teacher model who asks questions, provides clues to the students, and offers feedback and meaningful explanation if necessary (Rosenshine, 1980). In the present study, teachers' ineffectiveness is likely to be the reason of having no, or negative impact of this particular variable on students' mathematics achievement across the countries.

Studies have indicated that careful use of calculators improves student mathematics achievement and attitudes toward mathematics. Hembree and Dessart (1986) carried out a meta-analysis study about the use of a non-graphing calculator in the classroom and concluded that use of hand-held calculators improved student learning. However, in the present study, the findings about the use of calculators point out different impacts across the countries. In Belgium (Flemish), the scores of students whose teacher uses calculator 'hardly or never', were lower than the classes of teachers who use them more often, but this effect was opposite in Slovak Republic and Netherlands. As in the case of teaching methodologies, the use of calculator might also have different impacts on learning in mathematics, depending on how it is handled and used in the classroom. As was pointed out in the previous findings, in Belgium, all the teaching methods and technology, like calculators, are used in harmony with each other.

Literature states that teachers' conceptions about mathematics affect the instructional practices (Thompson, 1984). However, the result of the present study did not indicate any major contribution of "traditional approach" and "contemporary approach" variables on students' learning of mathematics. While the traditional approach indicates no impact at all, contemporary approach indicates diverse impact on learning. It has positive effect in Belgium and negative effect in Czech Republic. When the content of the questionnaire items are considered for these variables, it can be argued that teachers were not able to discriminate the idea presented in the items and responded in a way to foster both type of approaches in their teaching practices. For instance, when Turkish data were closely evaluated, it was observed that teachers may agree with both items in the same degree such as "Math is primarily an abstract subject" and "Math is formal representation of the world." which were imposing two contrary ideas.

Classroom Characteristics

The last group of variables namely class size, class climate and limitations to teaching indicated consistent results across the countries. In Belgium (Flemish), Hungary, Italy, Lithuania and Netherlands, it was found that class size had a positive significant effect on student achievement. This finding is consistent with the secondary analysis of the TIMSS data set (Martin et al., 2000). In general, as the class size increases, achievement scores in TIMSS increase as well. The reason of this finding was attributed to the fact that weaker students are generally assigned in the smaller classes. In some countries, remedial classes are constructed for less able and disabled students as well (Eurybase, 2006). In European Union countries, average class sizes is 22, on the contrary, this is 42 in Turkey. It seems that Turkish schools are far behind the ideal standards, since the maximum number of students in one class does not exceed 30 students in the European Union countries. The present study indicates that neither crowded classrooms nor classrooms with a very few students is ideal for a better educational outcomes.

Class climate is one of the most important predictor of school achievement in three countries in the full model. In Turkey, Slovak Republic and Italy, as classroom becomes quieter and orderly, students have higher scores in mathematics. This is an expected result and supported by other research studies as well (Papanastasiou, 2008). However, this does not mean a stressful and disciplined environment in the classroom, rather, student motivation and interest with the subject matter creates quiet classroom atmosphere.

In Belgium (Flemish), Italy, Slovenia and Netherlands, limitations to teaching had negative significant effect on mathematics achievement of students. In Turkey, this particular variable has no effect at all.

CONCLUSION

In sum, “home educational resources” is the most important variable interfering with the achievement measures of the students in all the countries. When this particular variable is controlled, limitations to teaching, class size and class climate are three variables moderately related to mathematics achievement. As expected, quiet classroom with average size of 22 students is a basic condition for higher achievement in mathematics.

Interestingly, re-teaching and clarification do not contribute to learning mathematics in any country. That might be the result of constituting ability groups in schools. It is very likely that students who consistently fail are grouped for re-teaching the mathematical concepts in schools that might develop negative academic self concept. Homework review almost has no effect at all, but emphasize on homework may be an effective tool, if it is in harmony with the other classroom activities. There is no best teaching method in the classroom, when lecture, guided practice and independent practice are considered. However, pair work does not function as expected in any country. This finding clearly supports the idea of using variety of teaching techniques in the classroom based on the cultural context, and the needs of the students. Emphasize on problem solving in the classroom clearly fosters learning in the European Union countries. However, if there is uncertainty about the meaning and conceptual definition of ‘mathematical problem’ among the teachers, it does not contribute to any learning. For such cases, textbook based teaching functions better than any other methods used in the classroom.

Following concluding remarks could be drawn for education policy makers;

1. “Home educational resources” is the only variable which has positive effect on learning mathematics across all the countries.
2. Teachers’ gender has an effect in achievement. However, in some countries male teachers are more successful than the female teachers. This might be the reflection of cultural differences.
3. Experience of a teacher seems an effective variable as long as the level of experience is not greater than 15 years in average.
4. Emphasize on homework review in classroom has no impact on learning in mathematics across all the countries. However, emphasize on homework might be an influential factor in a very few country.
5. Guided practice and independent practice have diverse impact on achievement across the countries but re-teaching and clarification carried out in the mathematics classrooms have no positive impact on learning across all the countries.

6. Small class size does not guarantee a successful learning outcome in mathematics.
7. Quiet atmosphere in the classroom is directly related to learning in mathematics.
8. Emphasize on problem solving in the successful countries is a good practice among the mathematics teachers to foster learning. However, the meaning of problem solving should be clarified among teachers in low achieving countries.
9. Textbook based teaching is an effective tool for low achieving countries.

REFERENCES

Bos, K. and Kuiper, W., (1999). Modelling TIMSS data in a European comparative perspective: Exploring influencing factors on achievement in mathematics in grade 8. *Educational Research and Evaluation*, 5(2), pp.157-179.

Bracey, G. W., (2003). Teachers around the world. Phi Delta Kappan, 85(3), pp.253-254.

Braswell,J.S., Lutkus, A.D., Grigg, W.S., Santapau, S.L., Tay-Lim, B., Johnson M (2001). *The Nation's Report Card: Mathematics 2000*. Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2001517 on 12 May 2008.

Brophy, J, & Good, T.L., (1986). Teacher behavior and student achievement. In M.C. Wittrock (Ed), *Handbook of Research on Teaching*, (3rd ed.). New York: Macmillan.

Cogan, L.S. & Schmidt, W. H., (1999). An examination of instructional practices in six countries. In G. Kaiser, E. Luna, & I. Huntley (eds). *International Comparisons in Mathematics Education*. London: Falmer Press.

Cooper, H., Robinson, J. C., & Patall, E. A. (2006). Does homework improve academic achievement? A synthesis of research. *Review of Educational Research*, 76, 1-62.

Davidson, N. (1985). Small group cooperative learning in mathematics: A selective view of the research. In R. Slavin (Ed.), *Learning to cooperate: Cooperating to learn* (pp.211-30) NY: Plenum.

Dee, T.S., (2006). The Why Chromosome: How a teacher's gender affects boys and *girls. Education Next* 6(4), pp. 68-75. Retrieved http://media.hoover.org/documents/ednext20064_68.pdf on 12 May 2008.

Eurybase: The information database on education systems in Europe, (2006). Retrieved from Eurydice: The information network on education in Europe Web site: http://oraprod.eurydice.org/portal/page?_pageid=197,161439&_dad=portal&_schema=PORTAL on 3 July 2008.

Farrow, S., Tymms, P. & Henderson, B., (1999). Homework and attainment in primary schools. *British Educational Research Journal*, 25(3), pp.323-41

Forgazs, H. & Leder, G. (2006). Work Patterns and Stressors of Experienced and Novice Mathematics Teachers. *Australian Mathematics Teacher*, 62(3) pp.36-40.

Foy, P., Joncas, M., (2000). *TIMSS Sample Design. In M.O. Martin, K.D. Gregory & S.E. Stemler (eds.) TIMSS 1999 Technical Report*. Boston College, Lynch School of Education.

Fullarton, S., Lokan, J., Lamb, S. & Ainley, J. (2003). *Lessons from the Third International Mathematics and Science Study,* TIMSS Australia Monograph No. 4. Melbourne: Australian Council for Educational Research.

Goldhaber, D.D. & Brewer, D.J., (1997). Evaluating the effect of teacher degree level on educational performance. In W.J. Fowler (ed), *Developments in School Finance, 1996.* Washington DC: National Center for Education Statistics, US Department of Education.

Gonzales, E.J. & Miles, J.A., (2001). *TIMSS 1999:User Guide for the International Database.* Boston College, Lynch School of Education.

Greenwald, R., Hedges, L., and Laine, R. (1996). The effect of school resources on student achievement. Review of Educational Research, 66(3), pp.361-396.

Harnischfeger & Wiley ref

Hembree, R. and Dessert, D.(1986). Effects Of Hand-Held Calculators In Precollege Mathematics Education: A Meta-Analysis. *Journal For Research In Mathematics Education.* 17(2) , p83-99.

Howie, S. J., (2003). Conditions of schooling in South Africa and the effects on mathematics achievement. *Studies in Educational Evaluation,* 29, pp.227-241.

Howie, S.J., (2005). Contextual Factors at the School and Classroom Level Related to Pupils' Performance in Mathematics in South Africa. *Educational Research and Evaluation,* 11(2), pp. 123-140

Jaan, M., (2006). Students' Homework and TIMSS 2003 Mathematics Results. Paper presented at the International Conference "Teaching Mathematics: Retrospective and Perspectives" (7th, Tartu, Estonia, May 12-13, 2006) ED491866

Kalender, İ. & Berberoğlu, G., (2009). An assessment of factors related to science achievement of Turkish students. *International Journal of Science Education*, 31(10), 1379-1394.

Keeves, J. P., (2001). Comparative research in education: IEA Studies. *International Encyclopedia of the Social and Behavioral Sciences.* In N.J. Smelser and P.B. Baltes (eds.). Oxford: Pergamon Press.

Koehler, M., and Grouws, D.A., (1992). Mathematics teaching practices and their effects. In D.A.Grouws (ed) *Handbook of Research on Mathematics Teaching and Learning*. New York: Macmillan.

Kyriacou, C., (1997). *Effective Teaching in Schools* . Cheltenham: Stanley Thornes Ltd.

Kulik, J., (1993). *An analysis of the research on ability grouping.* Retrieved from http://www.geniusdenied.com/articles/Record.aspx?NavID=13_15&rid=11496 on 25 September 2008.

Kupari, P., (2003). Instructional practices and teachers' beliefs in Finnish mathematics education. *Studies in Educational Evaluation, 29*, 243-257.

Martin, M.O., Mullis, I.V.S., Gregory, K.D., Hoyle, C and Shen, C., (2000). *Effective schools in science and mathematics: IEA's Third International Mathematics and Science Study*. Boston College, Lynch School of Education.

Mullis, I.V.S., Martin, M.O., Beaton, A.E., Gonzales, E.J., Kelly, D.L., Smith, T.A., (1997). *Mathematics achievement in primary school years: IEA's Third International Mathematics and Science Study*. Boston College, Center for the Study of Testing, Evaluation and Educational Policy.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: author.

Oakes, J. (1985) *Keeping track: How schools structure inequality*. New Haven, CT: Yale University Press.

Papanastasiou, C., (2008). A residual analysis of effective schools and effective teaching in mathematics. *Studies in Educational Evaluation*, 34(1), pp.24-30.

Papanastasiou, E., (2002). Factors that differentiate mathematics students in Cyprus, Hong Kong and the USA. *Educational Research and Evaluation: An International Journal on Theory and Practice*, 8(1), p129-46. (EJ649872)

Philippou, G.N. & Christou, C., (1999). Teachers' conceptions of mathematics and students' achievement: A cross-cultural study based on results from TIMSS. *Studies in Educational Evaluation*, 25, 379-398.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical Linear Models: Applications and Data Analysis Methods, Second Edition*. Newbury Park, CA: Sage.

Raudenbush, S. W.,Bryk T. and Congdon R. (2000). HLM 5: *Hierarchical, Linear and Nonlinear Modeling, Chicago, IL: Scientific Software International.*

Rivkin, S.G., Hanushek, E.A., & Kain, J.F. (2005). Teachers, schools, and academic achievement. *Econometrica*, 73(2), 417-458.

Rodriguez, M.C., (2004). The role of classroom assessment in student performance on TIMSS. *Applied Measurement in Education*,17(1),1-24.

Romberg, T.A. & Carpenter, T.P., (1986). Research on teaching and learning mathematics: Two disciplines of scientific inquiry. In M.C. Wittrock (Ed), *Handbook of Research on Teaching*, (3rd ed.). New York: Macmillan.

Rosenshine, B. & Stevens, R. (1986). Teaching functions. In M.C. Wittrock (Ed.) *Handbook of Research on Teaching, 3rd Edition*. New York, Macmillan.

Rosenshine, B.V. (1980). How time is spent in elementary classrooms. In C. Denham and A. Lieberman, *Time to learn*. Washington, DC: National Institute of Education.

Schmidt, W.H., McKnight, C.C., Cogan, L.S., Jakwerth, P.M., Houang, R.T. (1999). *Facing the Consequences: Using TIMSS for a Closer Look At U.S. Mathematics & Science Education*. Kluwer Academic Publishers.

Schreiber, J. B., (2002). Institutional and Student Factors and Their Influence on Advanced Mathematics Achievement. *Journal of Educational Research*, *95*(5), pp.274-86.

Simon, M., (1997). Developing new models of mathematics teaching: An imperative for research on mathematics teacher education. In E. Fennema & B.S. Nelson (eds). *Mathematics Teachers in Transition*, pp.55-86.

Slavin, R.E. (1990). Student team learning in mathematics. In N. Davidson (Ed.), *Cooperative learning in math: A handbook for teachers*. Boston: Allyn & Bacon, pp. 69-102.

Stemler, S.E. (2001). *Examining School Effectiveness at the Fourth Grade: A Hierarchical Analysis of the Third International Mathematics and Science Study (TIMSS)*. Dissertation Abstracts International, *62* (03A), p. 919.

Thompson, A., (1984). The relationship of teachers' conceptions of mathematics teaching to instructional practice. *Educational Studies in Mathematics*, *15*, pp.105-127.

Thompson, A., (1992). Teachers' beliefs and conceptions: A synthesis of the research. *Handbook of research on mathematics teaching and learning*. NCTM: Reston VA.

Van den Broeck, A., Opdenakker, M.-C., & Van Damme, J. (2005). The effects of student characteristics on mathematics achievement in Flemish TIMSS 1999 data. *Educational Research and Evaluation*, *11*(2), 107-121

Wayne, A. J. & Youngs, P., (2003). Teacher characteristics and student achievement gains: A review. *Review of Educational Research, 73* (1), pp.89-122.

Willms, J.D. & Smith, T. (2005). A Manual for Conducting Analyses with Data from TIMSS and PISA. Report prepared for UNESCO Institute for Statistics.

Yayan, B. & Berberoğlu, G., (2004). A re-analysis of the TIMSS 1999 mathematics assessment data of the Turkish students. *Studies in Educational Evaluation, 30*(1), pp.87-104.

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