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Research Article

Analysis of Student and School Level Variables Related to Mathematics Self-Efficacy Level Based on PISA 2012 Results for China-Shanghai, Turkey, and Greece

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Abstract

This study aims to analyze the student and school level variables that affect students' self-efficacy levels in mathematics in China-Shanghai, Turkey, and Greece based on PISA 2012 results. In line with this purpose, the hierarchical linear regression model (HLM) was employed. The interschool variability is estimated at approximately 17% in China-Shanghai, approximately 22% in Turkey, and approximately 23% in Greece. This study showed a positive association between variables of self-confidence, *teacher support*, and *attitude toward school*, all of which are among Level 1 variables, and mathematics self-efficacy in all three countries. A negative association was observed to exist between the variables *socio-cultural index* and *educational opportunities at home* and mathematics self-efficacy in all three countries. While *pre-school education* in China-Shanghai and Turkey were negatively associated with students' mathematics self-efficacy levels, the same variable was positively associated with students' mathematics self-efficacy in Greece. While the variable *mathematical anxiety* was negatively associated with students' mathematics self-efficacy in China-Shanghai and Greece, it was positively associated with students' mathematics self-efficacy in Turkey. The variable *interest in mathematics*, in turn, was negatively associated with mathematics self-efficacy solely in China-Shanghai. Regarding the association between mathematics self-efficacy levels and the school level variables, a near-zero positive association was found between *class size*, deemed significant for Turkey, and self-efficacy levels. The association between *teacher to student ratio in school* and self-efficacy levels was found to be negative in all three countries. The variable *teacher's morale*, however, was positively associated with self-efficacy level in China-Shanghai and Turkey.

Keywords

PISA project • Self-efficacy in mathematics • Hierarchical linear regression model • Student characteristics • School characteristics

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In today's globalized world, the notion of development has come to be contextualized in terms of such basic indicators as human capital, education, health, living standards, poverty, and equality, and to be evaluated using human development as its criterion (Firat & Aydın, 2015). Since education and skills are among the criteria used to identify living index – itself an indicator of development – these two variables constitute two of the basic criteria used to determine whether individuals have or have not achieved better living conditions. More specifically, educated individuals are more likely to attain better working conditions and higher income, on the one hand, and to be involved in a variety of non-economic activities, on the other. In this respect, it may be argued that the one's education level is directly related to his state of material well-being and that higher educational level leads to increased material well-being (Durand & Smith, 2013 as cited in Firat & Aydın, 2015). In order to increase their overall level of development and to achieve a higher life index, developing countries in particular attach special attention to education. Developing countries need large-scale test results to shape their educational policies and to improve their education system. In this regard, PISA, TIMMS, and PIRLS are examples of such exams applied at the international level that are used to measure and compare students' achievements in different countries.

Organized at three-year intervals by the Organization for Economic Cooperation and Development (OECD) (EARGED, 2010), PISA (Program for International Student Assessment) is just one examination aimed at the assessment of knowledge and skills acquired by 15 year old students. and Rather than measuring to what extent 15 year old students receiving formal education following compulsory education curriculums have learned the subjects (mathematical literacy, science literacy, and reading skills) dealt with in the curriculum, the PISA project aims to measure students' efficacy in making use of their acquired skills and knowledge in situations encountered in real life. The fundamental characteristic that distinguishes the PISA project from other projects is that it not only analyzes individuals' cognitive attributes, but also analyzes the affective factors relating to school and student characteristics.

It is quite important to identify to what extent such skills as mathematical literacy, science literacy, and reading skills are used in real life situations, as dealt with by the PISA project. The utilization of information learned at school in real life situations is an indicator of the fact that such information has not only been memorized, but internalized. Mathematical literacy, one of the areas that PISA measures, is the cognitive dimension that includes skills with which students in today's society should be equipped. Since many of the skills used in daily life, including counting, telling time, making payments while shopping, weighing and measuring, and graph reading, are related to mathematical concepts, it is only logical to say that mathematics is intertwined with real life and that it is a strength for one to know mathematics (Işık, Çiltaş, & Bekdemir, 2008). This is because mathematics is important for individuals

and societies in order not only to develop scientific thinking skills in line with living conditions, but also to apply such skills in their relevant areas. Beyond the skills related to one's ability to perform mathematical operations, the PISA project emphasizes the ability to use mathematics in daily life skills based on "analysis, reasoning, effective transmission of ideas, problem-solving in different situations, essaying, and interpretation."

It is important to examine the factors affecting literacy skills related to mathematics, which although occupy such a significant space in individuals' daily lives, are at the same time disliked, feared, and lead to anxiety. The most prominent of such factors related to students' mathematical literacy are socio-cultural index (Acar & Öğretmen, 2012; Bos & Kuiper, 1999; Dursun & Dede, 2004; Lee & Burkam, 2002; Lee & Ginsburg, 2007; Usta, 2014; Yalçın & Tavşancıl, 2014), self-efficacy (Bandura & Schunk, 1981; Betz & Hackett, 1981; Joo, Bong, & Choi, 2000; Parajes, 1996; Parajes & Miller, 1994; Pintrich & De Groot, 1990), self-confidence (Akyüz & Pala 2010; Chui & Classen, 2010; Güzel, 2006; Wilkins, 2004), and attitude towards school, (Hammouri, 2004; İş Güzel, 2006; Ma, 1997; Papanastasiou, 2000).

Considering all of these factors, that of self-efficacy in mathematics is both directly and highly correlated with mathematic achievement. Bandura defines self-efficacy as one's self-perception about his/her capacity to organize and successfully fulfill the activities necessary to achieve a certain level of performance, considering it to be from among those features that affect the formation of behaviors and is defined (Bandura, 1997, p. 1 as cited in Aşkar & Umay, 2001). Self-efficacy is also defined as one's belief in his/her own ability to start and complete tasks that have an effect on things happening in one's environment (Bandura, 1994). Rather than being skilled, self-efficacy corresponds to one's belief in his/her own ability to successfully complete a task. An individual who has not attained a sufficient degree of self-efficacy will not be able to take action. In this respect, the concept of self-efficacy involves the elements following elements: planning actions, being aware, having attained the required skills, and being motivated after reviewing difficulties and possible gains (Yıldırım & İlhan, 2010). The main difference between those who have a high level and those who have a low level of self-efficacy is that the former pull themselves together and take new action following failure (Bandura, 1997). Bandura emphasizes that self-efficacy is based on four sources: (1) one's previous performances and life experiences, (2) one's emotional situation based on his/her psychological situation at the time of the behavior being realized, (3) one's indirect experiences based on his/her observation of others' achievements, and (4) verbal persuasion based on encouragement and advice from others. In consideration of the aforementioned, a high level of self-efficacy not only enables individuals to set higher goals for themselves, but also to better aware of what decisions they are making, which in turn affects their cognitive

processes (Locke & Latham, 1990). Generally defined as one's potential belief in his/her achievement in a task, self-efficacy is labeled by PISA as a variable of students' feeling of self-competency in mathematics. Taking mathematics as the basis among cognitive processes, the PISA 2012 project focuses on self-efficacy in mathematics with students' levels of self-efficacy in mathematics being associated with how they perceive their own levels of self-competency, concerning in particular their abilities to successfully complete the tasks defined in the PISA student survey. This study also aims to analyze the variables associated with self-efficacy in mathematics in order to identify students' potential to succeed in mathematics.

Self-efficacy is an effective criterion to measure individuals' achievements in mathematics (Dede, 2008). Self-efficacy in mathematics is defined as one's belief in his/her own ability to complete mathematics related tasks (Ural, Umay, & Argün, 2008). Due to its critical role in identifying overall student achievement, the relationship between self-efficacy and achievement in mathematics has been a subject of study in the literature. Hackett and Betz (1989) suggest that according to the social cognitive theory, the source of mathematical anxiety is low self-efficacy in mathematics. Cooper and Robinson (1991) suggest that self-efficacy in mathematics has a negative association with mathematical anxiety and a positive association with performance in mathematics. Again, Pajares and Kranzler (1995) report that students' self-efficacy in mathematics has strong effects on both mathematical anxiety and problem-solving performance. In their study, Randhawa, Beamer, and Lundberg (1993) suggest that self-efficacy in mathematics is a mediating variable between one's attitude toward mathematics and achievement in mathematics.

In consideration of the foregoing, the purpose of this study is to analyze the variables that affect the self-accuracy variable, whose relationship with mathematical literacy performance is important within the PISA project since it allows for comparisons to be made at an international level. It is important to note the differences and similarities that appear after comparing variables affecting mathematics self-efficacy levels in Shanghai, China, which had the highest performance level in mathematical literacy according to PISA 2012 results, and Greece, which not only has an educational system similar to that of Turkey (Erginer, 2006; Saylık, 2014), but also similar performance levels in PISA surveys. Furthermore, this study distinguishes itself from previous studies in that it focuses on mathematics self-efficacy levels, taking them, as opposed to mathematical literacy, as a significant predictor of achievement in mathematics.

Lee (2009) reported that while students in Asian countries (Korea, Japan, Thailand, etc.) projects demonstrated low levels of self-efficacy in mathematics and high levels of mathematical anxiety in PISA 2003, students in central European countries (Austria, Germany, Sweden, etc.) showed high levels of mathematics self-efficacy

and low levels of mathematical anxiety. His interpretation is that this resulted from the fact that a competitive learning environment exists in Asian schools, that families have high academic expectations for students, and that students believe that it is quite important to pass entrance exams, all of which in turn support high levels of anxiety and low levels of self-efficacy. The fact that Turkey has conditions similar to that of Shanghai, China, an Asian country, with respect to the aforementioned, and has an educational system similar to that of Greece, a European country, makes this comparison important. In this respect, the current study is also important, as it provides an opportunity not only to compare different countries, but also to take the necessary measures and to promote relevant amendments both in the educational system and in the affective characteristics of students. Another way that this study distinguishes itself from others is that it analyzes the variables related to students' self-efficacy beliefs within the context of the PISA 2012 project. Such a context is important because it has been found that one's self-efficacy belief is highly associated with achievement in mathematics and the PISA 2012 focuses on mathematical literacy at a cognitive level.

Purpose

The purpose of this study is to identify which student and school level factors are related to students' mathematics self-efficacy levels in China-Shanghai, Turkey, and Greece, all of which participated in the PISA 2012, and to reveal differences between these countries.

In line with the abovementioned purpose, answers to the following questions were sought:

1. Is there a significant difference between the schools in China-Shanghai, Turkey, and Greece with respect to students' levels of mathematics self-efficacy?
2. What are the student level factors related to students' levels of mathematics self-efficacy in China-Shanghai, Turkey, and Greece?
3. What are the school level factors related to students' levels of mathematics self-efficacy in China-Shanghai, Turkey, and Greece?

Method

Research Design

This research, which aims to identify the student and school level factors related to students' level of self-efficacy in mathematics in China-Shanghai, Turkey, and Greece, which participated in PISA 2012, is based on the screening model

Universe and Sampling

This study is based on the same population and sample that was used as the basis of the PISA study. Since class level is not considered as an international criterion in the PISA study, age is selected as one of the criteria that would be used to identify the population. The age criterion is identified as being between 15 years and 3 months and 16 years and 2 months ([Organization for Economic Cooperation and Development \[OECD\], 2007](#)).

In the present study, the number of schools and students participating in the PISA 2012 project have been taken as the basis: 155 schools and 5,177 students in China-Shanghai, 170 schools and 4,818 students in Turkey, and 188 schools and 5,079 students in Greece. In order to estimate the population parameters based on the sample selected before analyzing the research data and in order to eliminate any bias based on the fact that selection probability was not equal for all units in the population, the sample was weighted (OECD, 20015). In this study, the PISA data were weighed according to the “final student weight” (W_FSTUWT) variable.

Data and Data Collection

Surveys, including cognitive level tests, were used as data collection tools in PISA studies. Cognitive tests were used to measure students’ cognitive competencies in reading skills, mathematical literacy, and science literacy, as these formed the basis of the survey. Separate surveys were also used to identify factors affecting countries’ educational systems.

Student and school level variables used while performing research were identified in consideration of the subjects dealt with in the context of the PISA survey. Of the variables analyzed, those related to students consist of “participation in preschool education,” “educational opportunities at home,” “interest in mathematics,” “self-confidence,” “mathematical anxiety,” “teacher support,” and “attitude towards school;” and those related to schools were “class size,” “rate of mathematics teachers at school,” and “teacher’s morale.”

In line with the OECD report, survey items related to student and school level variables are summarized in Table 1 along with their definition and observations.

The relevant data were downloaded from the website www.pisa.oecd.org in notepad format. After the data were transferred to SPSS 12, the researchers identified which data was related to China-Shanghai, Turkey, and Greece.

Table 1
Survey Items and Implicit Variables Identified

IMPLICIT VARIABLES	DEFINITION	OBSERVED VARIABLES (ITEM CODES IN PISA DATA FILE)
<i>Student Level Variables</i>		
Participation in Pre-school Education (OOEGT)	This variable aims to determine whether students attended preschool education before primary education in order to be prepared for school.	This was observed in Item No. ST05Q01 in the Student Survey.
Socio-Cultural Index (SOSKULINDK)	The socio-cultural index was produced in order to illustrate the professional status of families of students as well as their home history.	In line with the calculation described for PISA data, the item coded as ESCS was used.
Educational Opportunities at Home (ESEO)	Educational opportunities at home were identified by asking students whether they have the indicated educational resources at home. The scaling of this variable was calculated based on the item response theory, with positive values showing a high level of educational resources at home (OECD, 2004).	In line with the calculation described for PISA data, the item coded as HEDRES was used.
Mathematical Anxiety (MK)	This reflects the anxiety, distress, and negative emotional status students experienced while dealing with mathematics.	ST42Q01 ST42Q03 ST42Q05 ST42Q08 ST42Q10 ST42Q02 ST42Q04
Self-Confidence in Mathematics (MOZG)	This reflects one's belief in himself/herself regarding his/her ability to deal with mathematical situations.	ST42Q06 ST42Q07 ST42Q09 ST29Q01
Interest in Mathematics (Mĭ)	This reflects the extent to which students are interested in and enjoy mathematics.	ST29Q03 ST29Q04 ST29Q06 ST83Q01
Teacher Support (ÖD)	This shows the extent to which teachers stand by and support their students in cases relating to school.	ST83Q02 ST83Q03 ST83Q04 ST88Q01 ST88Q02
Attitude Towards School (OT)	This expresses students' positive or negative opinions about school and their judgments about the contributions that school makes in preparing them for adult life.	ST88Q03 ST88Q04 ST89Q02 ST89Q03 ST89Q04 ST89Q05
<i>School Level Variables</i>		
Class Size (SB)	This represents the number of students in a classroom.	This was observed in Item No. CLSIZE in the Student Survey.
Rate of Mathematics Teachers at School (MÖO)	This represents the number of students per mathematics teacher at school.	This was observed in Item No. PROPMATH in the Student Survey.
Teacher's Morale (ÖM)	This reflects the affective dimension relating to teachers' motivations and desires.	SC03Q01 SC26Q01 SC26Q02 SC26Q03 SC26Q04

Data Preparation

Each of the three countries' data were prepared in two categories: The first being Level 1 data files, which include student characteristics, and the second being Level 2 data files, which include school characteristics. Researchers checked whether the construct validity for items of the potential variables dealt with in the research were satisfied for China-Shanghai, Turkey, and Greece by conducting Confirmatory Factor Analyses.

Those data files having a satisfactory construct validity were the first to be accommodated for ADM by eliminating lost values and extreme values from the data files. Although no extreme value was observed in the data, since the ADM was sensitive to lost data in the second level data file, an average value was assigned for lost values present in Level 2 data.

Before starting the ADM, the Level 1 and Level 2 variables were checked to determine whether multicollinearity was a problem. The results indicated that no such problem existed in either the Level 1 or Level 2 variables for data pertaining to China-Shanghai, Turkey, or Greece's PISA 2012.

When performing an ADM, a number of statistical assumptions should be satisfied for each level. The assumptions analyzed in an ADM are as follows:

- The assumption of normality of errors for Level 1
- For Level 1 units, each r_{ij} has a normal distribution whose average is zero.
- Level 1 variables are independent from r_{ij} .
- Level 2 errors show multi-normality whose average is zero.
- Level 2 predictors are independent from u_{qj} .
- Level 1 and Level 2 errors are independent from each other.
- Predictors in any level do not have an association with random effects in other levels.

After it was confirmed that relevant assumptions were satisfied, the data was analyzed by conducting an ADM.

Data Analysis

PISA data have a hierarchical structure. The data were collected from two different, yet intertwined units: students and schools. Students were selected from schools. Students constituted the first level (Level 1) and schools constituted the second level (Level 2), which also involved the first level. The research data were analyzed on the basis of the Two Level Hierarchical Linear Modelling.

In line with the study’s set purposes, the Random Effect One-Way ANOVA Model, Random Coefficients Model, and the Regression Model Where the Averages are Outputs were used.

Centralization: There are two types of centralization in hierarchical linear models. One is based on group average and the other on weighted average. For intertwined structures, centralization based on group average is generally suggested for the subset, while centralization based on weighted average is generally suggested for the set that covers the subset (Raudenbush & Bryk, 2002). Centralization is done in order to make a more meaningful interpretation. In thus study, Level 1 variables were centralized based on the weighted average and Level 2 variables were centralized based on the group average.

Results

Based on the research questions, findings related to student level and school level variables have been presented for each of the three countries.

Identification of Differences between Schools in China-Shanghai, Turkey, and Greece on the Basis of the PISA 2012 Results

For each of the three countries, it was first determined as to whether a differentiation existed among the schools. The Random Effect One-Way ANOVA Model was used for that purpose. The first and second phase models developed for this model are as follows:

$$\text{First phase model: } Y_{ij}|ÖZYET = \beta_{0j} + r_{ij}$$

$$\text{Second phase model: } \beta_{0j} = u_{0j}$$

The constant effect results of the Random Effect One-Way ANOVA Model developed according to this equation are given in Table 2.

Country	Constant Effect	Coefficient	Standard Error	t-Value
China-Shanghai	For Constant β_{0j}	1.496	0.018	82.321
	Average School Average γ_{00j}			
Turkey	For Constant β_{0j}	1.980	0.0170	116.178
	Average School Average γ_{00j}			
Greece	For Constant β_{0j}	2.182	0.013	173.977
	Average School Average γ_{00j}			

According to the One-Way ANOVA Model, there was a significant difference in students’ mathematics self-efficacy points according to the PISA 2012 data ($p < .01$) among the schools in China-Shanghai, Turkey and Greece. The coefficients

estimated based on schools' average mathematics self-efficacy points were 1.496 for China-Shanghai, 1.980 for Turkey, and 2.182 for Greece. It was observed that Greece's average mathematics self-efficacy score was higher than those of both China-Shanghai and Turkey. In order to determine whether the differences among schools with respect to their mathematics self-efficacy points were random, a One-Way ANOVA Model was analyzed, with random effect results presented in Table 3.

Table 3
Random Effect Results of the Differences Among Schools for China-Shanghai, Turkey, and Greece's PISA 2012

Country	Random Effect	Variance	sd	X ²
China-Shanghai	School average, u _{0j}	0.046	154	1571.966
	Level 1 effect, r _y	0.169		
Turkey	School average, u _{0j}	0.039	169	1091.842
	Level 1 effect, r _y	0.215		
Greece	School average, u _{0j}	0.019	187	603.164
	Level 1 effect, r _y	0.232		

According to the PISA 2012 data, the variance of the differences between the school performance and the school average (intraschool variability - u_{0j}) was ≈5% in China-Shanghai, ≈4% in Turkey, and 2% in Greece. The variance of the difference between the school averages and the general average (interschool variability- r_y) was estimated at ≈17% in China-Shanghai, ≈22% in Turkey, and ≈23% in Greece.

When the random effect of the One-Way ANOVA Model was analyzed, it was found that the random effect of the variance at school level was significant in all three countries (X² = 1571.966 sd = 154, p < .01, X² = 1091.842 sd = 169 p < .01 and X² = 603.164 sd = 187 p < .01). This shows that the differences among schools with respect to their average mathematics self-efficacy points were random. Furthermore, interclass correlation was calculated by dividing the Level 2 variance by the total variance, with China-Shanghai's interclass correlation score being ≈23%, Turkey's ≈15%, and Greece's ≈8%.

$$\rho_{\text{CLN}} = \frac{\tau_{00}}{\tau_{00} + \sigma^2} = \frac{0.05}{0.05 + 0.17} = 0.23$$

$$\rho_{\text{TR}} = \frac{\tau_{00}}{\tau_{00} + \sigma^2} = \frac{0.04}{0.04 + 0.22} = 0.15$$

$$\rho_{\text{YUN}} = \frac{\tau_{00}}{\tau_{00} + \sigma^2} = \frac{0.02}{0.02 + 0.23} = 0.08$$

These values suggest that the differences observed in mathematics self-efficacy points for China-Shanghai, Turkey, and Greece, according to the PISA 2012 data, approximately 23%, 15%, and 8%, respectively, were due to the interschool

differences with respect to mathematics self-efficacy points, whereas approximately 77%, 85%, and 92%, respectively, were due to personal differences among students. Furthermore, interclass correlation is an index showing to what extent student performances in the same school are similar to student performances in different schools (Raudenbush and Bryk, 2002). The interclass correlation coefficient supports the use of a two-level hierarchical model, meaning that differences are observed between intertwined sets and that it is significant to identify such differences.

When the researchers analyzed the Level 1 coefficients' degree of reliability, they found the reliability of coefficients to be .90, .80, and .65, respectively, for China-Shanghai, Turkey, and Greece. Since the degree of reliability determines whether or not the average derived from the sample represents the real school average, the results found show that the average derived from the sample is in fact a reliable indicator of the real school average.

Identification of Student Level Variables Related to Mathematics Self-Efficacy in China-Shanghai, Turkey, and Greece Based on the PISA 2012 Results

In order to identify which student characteristics were related to mathematics self-efficacy, a Random Coefficient Model was constructed. In this model, there were no Level 2 independent variables, which explain the constant and slope parameter. The Level 1 equation for the model constructed for the study's second sub-problem.

For the first phase:

$$Y_{ij}\text{ÖZYET} = \beta_{0j} + \beta_{1j}(\text{OOEGT}) + \beta_{2j}(\text{SOSKULINDK}) + \beta_{3j}(\text{ESEEO}) + \beta_{4j}(\text{MI}) + \beta_{5j}(\text{MK}) + \beta_{6j}(\text{MÖZG}) + \beta_{7j}(\text{OD}) + \beta_{8j}(\text{OT}) + r_{ij}$$

Model for the second phase:

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + u_{0j} \\ \beta_{1j} &= \gamma_{10} + u_{1j} \\ &\dots \\ \beta_{8j} &= \gamma_{80} + u_{12j} \end{aligned}$$

The symbols in the equation signify the following:

β_{0j} , the average mathematics self-efficacy score for j schools,

$\beta_{1j} \dots \beta_{8j}$ the average differences between mathematics self-efficacy scores based on student level variables,

γ_{00} , values of constant parameters expected on Level 2 units,

γ_{10} , values of slope parameters expected on Level 2 units,

u_{0j} , differences in slope parameters relating to the j th unit of Level 2.

While constructing a Random Coefficient Regression Model, data related to the first level can be either jointly or individually included in the model. [Raudenbush and Bryk \(2002\)](#) suggest analyzing each student level variable by including them individually in the model since the individual inclusion of variables ensures that the combined model is correct. In the current study, the student level variables were included separately in the model. The researchers identified whether mathematics self-efficacy levels were able to be predicted and whether the slopes had random or constant effects. Since the inclusion of variables that do not predict mathematics self-efficacy decreases the probability of whether the sample represents the population, such variables were excluded from the model.

Mathematics self-efficacy scores were evaluated based on the PISA 2012 data. All of the eight student level variables, whose effects were tested, were found to be significant for all three countries. Thus, all student level variables addressed in the Random Coefficient Regression Model constructed for all three countries were included in the model and tested.

Among the variables whose constant effects were analyzed individually for all three countries, the estimates of constant and random effects included in the model developed with significant student level variables are given in Table 4 and Table 5.

Table 4
Constant Effect Results of Student Level Variables that Affect Self-Efficacy in Mathematics in China-Shanghai, Turkey, and Greece Based on PISA 2012 Data

Constant Effect	Constant			SE			t		
	Chi-na-Shn	Tr	Gr	China-Shn	Tr	Gr	China-Shn	Tr	Gr
Average Mathematics Self-Efficacy Score	1.487	1.973	2.170	0.011	0.012	0.006	133.508	166.963	369.726
OOEGT	-0.103	-0.060	0.012	0.013	0.009	0.009	-7.708	-6.507	1.329
SOSKULINDK	-0.057	-0.032	-0.071	0.007	0.006	0.006	-8.427	-4.950	-12.291
ESEO	-0.050	-0.049	-0.049	0.006	0.006	0.006	-8.549	-8.123	-8.854
MÍ	-0.006	0.072	0.096	0.014	0.017	0.013	-0.434	4.347	7.301
MK	-0.192	0.082	-0.139	0.013	0.011	0.010	-15.193	7.204	-13.400
MÖZG	0.157	0.376	0.483	0.012	0.017	0.021	12.596	22.686	22.861
OD	0.103	0.089	0.021	0.011	0.014	0.011	8.954	6.265	1.898
OT	0.159	0.190	0.035	0.019	0.018	0.018	8.287	10.575	1.986

* The student level continuous variables were centralized on the basis of the group average and then analyzed.

According to the results of the random coefficient regression model, it is expected that when student level variables are equal to the group average, students' mathematics self-efficacy scores will be 1.49 in China-Shanghai, 1.97 in Turkey, and 2.17 in Greece. This means that Greek students' mathematics self-efficacy scores are higher than those of students in China-Shanghai and Turkey when student level variables are included.

Such variables as of confidence in one's mathematics skills, teacher support, and attitude toward school are positively associated with self-efficacy in mathematics in all three countries. A one-unit change in the variables *confidence in one's mathematics skills*, *teacher support*, and *attitude toward school* led to increases of 0.157, 0.103, and 0.159 units, respectively, in China-Shanghai, and increases of 0.376, 0.089, and 0.190 units, respectively, in Turkey. For Greece, it led to increases of 0.483, 0.021, and 0.035 units, respectively. A negative association between the variables *socio-cultural index* and *educational opportunities at home*, on the one hand, and *mathematics self-efficacy*, on the other, was observed in all three countries. A one-unit increase in the variables *socio-cultural index* and *educational opportunities at home* led to decreases of 0.057 and 0.050 units, respectively, in students' mathematics self-efficacy levels in China-Shanghai. The same led to decreases of 0.032 and 0.049 units, respectively, in Turkish students, and decreases of 0.071 and 0.049 units, respectively, in Greek students.

While pre-school education in China-Shanghai and Turkey were negatively associated with students' mathematics self-efficacy levels, it was positively associated with students' mathematics self-efficacy in Greece. While a one-unit change in the variable *preschool attendance* led to a decrease of 0.103 units for students in China-Shanghai and a decrease of 0.06 units for students in Turkey, the same led to an increase of 0.012 units for students in Greece. While the variable *mathematical anxiety* was negatively correlated with mathematics self-efficacy in China, it was positively correlated in Turkey. While a change of one unit in the variable *mathematical anxiety* resulted in a decrease of 0.192 units and of 0.132 in China-Shanghai Greece, respectively, it resulted in an increase of 0.082 units in Turkey. The variable *interest in mathematics*, in turn, had a negative association with mathematics self-efficacy only in China-Shanghai; a change of one unit in this particular variable resulted in a decrease of 0.006 units in mathematics self-efficacy.

The relation between variables' fixed and random effects is presented in Table 5.

Table 5 shows that among the student level variables that were analyzed in relation to their random effects (pre-school education, socio-cultural index, interest in mathematics, mathematics anxiety, and attitudes toward school), while only the variables *interest in mathematics* and *teacher support* had significant effects in Turkey, in Greece the variables *socio-cultural index*, *interest in mathematics*, *confidence in one's mathematics skills*, and *teacher support* ($p < .05$) had significant

Table 5
Random Effect Results of the Student Level Variables that Students' Affected Self-Efficacy Levels in China-Shanghai, Turkey, and Greece according to PISA 2012 Data

Random Effect	Variance			x ²		
	China-Shn	Tr	Gr	China-Shn	Tr	Gr
School average, u_{00}	0.016	0.018	0.002	568.381	527.003	245.117
OEGT u_{10}	0.006	0.001	0.002	191.037	156.558	186.044
SOSKULINDK u_{20}	0.002	0.000	0.001	199.498	163.194	195.733
ESEO u_{30}	0.001	0.000	0.001	162.715	152.360	158.744
Mİ u_{40}	0.010	0.018	0.010	201.065	264.105	216.906
MK u_{50}	0.003	0.003	0.003	181.887	173.242	145.837
MÖZG u_{60}	0.002	0.008	0.024	142.614	164.770	206.274
OD u_{70}	0.001	0.007	0.003	159.553	197.596	197.377
OT u_{80}	0.009	0.004	0.005	175.566	141.032	161.609
Level 1 effect, r_{ij}	0.109	0.123	0.113			

effects. This means that not only do the variables with significant random effects in China-Shanghai have a vertical axis compared to other schools, but also that the correlation between mathematics self-efficacy levels and the variables *socio-cultural index, interest in mathematics, mathematics anxiety, and attitude toward school* was higher in some schools. This indicates that some differences resulted from school level variables. In Turkey and Greece, the regression index of student level variables with significant random effects were similar in all schools, meaning that the correlation between student level variables and mathematics self-efficacy are approximate in different schools.

To calculate the degree of student level variance, one-way variances with random effects in the ANOVA model were compared with variances in the random effect regression model.

$$\text{Proportion variance explained at level 1} = \frac{\sigma^2(\text{random ANOVA}) - \sigma^2(\text{Self - Efficacy})}{\sigma^2(\text{random ANOVA})} \square$$

$$\text{Proportion variance explained at level 1}_{CIN-SHN} = \frac{0.169 - 0.109}{0.169} = 0.36$$

$$\text{Proportion variance explained at level 1}_{TR} = \frac{0.215 - 0.123}{0.215} = 0.43$$

$$\text{Proportion variance explained at level 1}_{FIN} = \frac{0.232 - 0.113}{0.232} = 0.51$$

When related values were integrated into the formula, it was found that both pre-school education and the variables *socio-cultural index, interest in mathematics, mathematics anxiety, and attitudes toward school* explained approximately 36% of student level variance in China-Shanghai for those variables with a significant random effect. In Turkey however, the variables *interest in mathematics* and *teacher*

support were found to explain approximately 43% of student level variance. Finally, the variables *socio-cultural index*, *interest in mathematics*, *confidence in one's mathematics skills*, and *teacher support* were found to explain approximately 51% of student level variance in Greece.

The reliability of constant and slope coefficients were analyzed in order to determine how reliable the model's sample was. Taking this into consideration, the reliability of the constant coefficient (β_{0j}) and slope coefficient are given in Table 6.

Table 6
The Reliability of the Constant and Slope Coefficients for China-Shanghai, Turkey, and Greece According to PISA 2012 Data

Level 1 Random Coefficient	Reliability Estimation		
	China-Shn	Tr	Gr
Average Mathematics Self-efficacy	0.674	0.656	0.213
OOEGT	0.176	0.075	0.080
SOSKULINDK	0.164	0.043	0.080
ESEO	0.086	0.059	0.095
Mİ	0.268	0.344	0.274
MK	0.083	0.098	0.103
MÖZG	0.044	0.139	0.242
OD	0.021	0.167	0.086
OT	0.113	0.054	0.063

Table 6 shows constants' reliability scores to be 0.67, 0.66, and 0.21 for China-Shanghai, Turkey, and Greece, respectively. The reliability of slope values indicates that there was a change of 0.27 and 0.021 points, meaning that slopes are less reliable. According to [Raudenbush and Bryk \(2002\)](#), the reason for low-level slope reliability is that the slope variant of the student level predictor variable is lower than the variant of the predicted variable. Accordingly, variables with more than 0.05 reliability can be taken as reliable variables. Additionally, reliability levels higher than 0.05 indicate that these coefficients change randomly according to schools. In China-Shanghai, only the reliability of the variable *teacher support* was found to be below 0.05, indicating that this variable shows a similar inclination in schools.

Determining School Level Variables Related to Students' Self-efficacy Levels According to the Results of the PISA 2003

Since schools' characteristics are known to affect students' mathematics self-efficacy levels, a model in which averages are outputs was constructed in order to determine schools' characteristics. Within this model, mathematics self-efficacy levels were attempted to be predicted without using any Level 1 variables, and instead using Level 2 variables.

The Level 1 equation in this model:

$$Y_{ij}|\ddot{OZYET} = \beta_{0j} + r_{ij}$$

The Level 2 equation:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} SB + \gamma_{02} M\ddot{O}O + \gamma_{03} \ddot{O}M$$

Symbols used in the above equations:

β_{0j} , j average a school's self-efficacy levels

γ_{00} , expected level of a constant parameter on Level 2 units (the average of school averages in terms of self-efficacy in mathematics)

$\gamma_{01}, \dots, \gamma_{04}$, changing effects of school level variables on school average self-efficacy levels

Raudenbush and Bryk (2002) suggest that in studies focusing on explaining a model, Level 2 variables should be analyzed according to the categories constructed and that the analysis should be repeated using significant variables. Since in this study, the variables represent independent characteristics, they were first analyzed separately. Following the first analysis, the meaningful variables were integrated into the model and tested altogether.

To determine which Level 2 variables had an influence on mathematics self-efficacy in the PISA 2012, constant and random effect values calculated separately for class size, the ratio of mathematics teachers, and teacher motivation were significant only in the mathematics teacher ratio and teacher motivation in China-Shanghai; class size, ratio of mathematics teacher, and teacher motivation in Turkey; and mathematics teacher ratio in Greece.

Constant and random coefficients that were found to have significant effects in all three countries are given in Table 7.

In the regression model results, in which the average is the output are analyzed, the variables *mathematics teacher ratio* and *teacher motivation* ($\gamma_{20} = -1.810$, SE = 0.350 $p < .001$ and $\gamma_{30} = 0.095$, SE = 0.037 $p < .001$) were found to have a significant impact on mathematics self-efficacy levels in the PISA 2012 for China-Shanghai. According to this result, it can be stated that students' mathematics self-efficacy levels decrease as the number of mathematics teachers to students increases: A one-unit increase in the number of students per mathematics teachers was found to cause a decrease of 1.810 units in students' self-efficacy levels. In contrast, as teachers' motivation increased, so did student's levels of self-efficacy: A one-unit increase in teacher motivation resulted in an increase of 0.095 units in students' mathematics self-efficacy levels. The significant variables

Table 7
PISA 2012 Constant and Random Effect Results of School Level Variables on Self-efficacy in Mathematics Levels

Constant Effect	Constant			SE			t		
	China-Shn	Tr	Gr	China-Shn	Tr	Gr	China-Shn	Tr	Gr
Average school effect γ_{00}^*	1.495	1.988	2.190	0.016	0.014	0.011	93.228	140.132	197.181
SB γ_{10}	-	0.003	-	-	0.001	-	-	2.232	-
MÖO γ_{20}	-1.810	-1.843	-2.513	0.350	0.268	0.356	-5.171	6.866	-7.059
ÖM γ_{30}	0.095	0.104	-	0.037	0.038	-	2.601	2.701	-
Random Effect	Variance			sd			χ^2		
School average, u_{0j}	0.036	0.027	0.013	0.189	0.163	0.113	1219.954	759.40528	460.58210
Level 1 effect, r_{ij}	0.170	0.215	0.232	0.411	0.463	0.482			

for Turkey were *class size*, *ratio of mathematics teachers*, and *teacher motivation* ($\gamma_{10} = 0.003$, $SE = 0.001$, $p < .001$ $\gamma_{20} = -1.843$, $SE = 0.268$, $p < .001$ and $\gamma_{30} = 0.104$, $SE = 0.038$, $p < .001$). Although the effect of the variable *class size* on students' mathematics self-efficacy levels was significant, it had only a minor effect. In other words, a one-unit increase in the number of students resulted in an increase of 0.003 units in students' mathematics self-efficacy levels. Nevertheless, similar to the China-Shanghai results, as the ratio of mathematics teachers increased, students' self-efficacy levels decreased. A one-unit increase in the ratio of mathematics teachers resulted in a decrease of 1.843 units in students' self-efficacy levels. In contrast, teacher motivation was found to have a positive effect on self-efficacy levels. A one-unit increase in teacher motivation resulted in an increase of 0.104 units in students' mathematics self-efficacy levels. In terms of Greek students' mathematics self-efficacy, it was found that from among school level variables, only the ratio of mathematics teachers was significant ($\gamma_{20} = -2.513$, $SE = 0.356$, $p < .001$). A negative and significant correlation was found between the ratio of mathematics teachers and self-efficacy levels in Greece, as well. A one-unit increase in the ratio of mathematics teachers resulted in a decrease of 2.513 units in students' self-efficacy levels.

In order to determine the degree to which significant Level 2 variables explain Level 2 variance, the regression models' variance levels, in which models the average is the output, were compared using the variance values formula:

$$\frac{\tau_{00}(\text{random ANOVA}) - \tau_{00}(\text{MEAN Self - Efficacy})}{\tau_{00}(\text{random ANOVA})}$$

derived from the random ANOVA model. The τ_{00} values calculated for all three countries are given in Table 8 along with their values.

Table 8
The results of τ_{00} values calculated for China-Shanghai, Turkey, and Greece

	China-Shanghai	Turkey	Greece
Regression model variants in which models the average is the output	0.036	0.027	0.013
ANOVA model variants with a random effect	0.046	0.039	0.019
Result	0.22	0.31	0.32

According to Table 8, the variables *ratio of mathematics teachers at school* and *teacher's morale*, both of which are Level 2 variables, explain 22% of Level 2 variance. For Turkey, the variables *class size*, *ratio of mathematics teachers at school*, and *teacher's morale* explain 31% of Level 2 variance. For Greece, the variable *ratio of mathematics teachers at school* explains 32% of Level 2 variance.

Discussion

According to the results of this study, which is based on the PISA 2012 results and which aims to explain whether students' levels of self-efficacy in mathematics differ between schools in China-Shanghai, Turkey, and Greece and, if there is a differentiation, to identify which student level and school level variables are accountable for such differentiation, it was found that students' levels of self-efficacy in mathematics differ between schools in all three countries. Intra-school differentiation was found to be $\approx 5\%$ in China-Shanghai, $\approx 4\%$ in Turkey, and $\approx 2\%$ in Greece. Inter-school differentiation, in turn, was estimated at $\approx 17\%$ in China-Shanghai, $\approx 22\%$ in Turkey, and $\approx 23\%$ in Greece. This means that in all three countries, while students at the same school show similar characteristics, students from different schools display different characteristics. In order to provide an account for such differentiation, the variables *preschool attendance*, *socio-cultural index*, *educational opportunities at home*, *interest in mathematics*, *self-confidence*, *mathematical anxiety*, *teacher support*, and *attitude toward school* were taken as student-level variables while *class size*, *ratio of mathematics teachers*, and *teacher's morale* were taken as school-level variables.

Among the student-level variables, self-confidence in mathematics was positively associated with mathematics self-efficacy in all three countries. This means that for all three countries, the higher a student's confidence in his mathematics skills, the higher his self-efficacy is in mathematics lessons. However, while one's having confidence in his mathematics skills made a higher contributed to students' self-efficacy levels in Greece and Turkey, it made a lower, albeit still positive, one in China-Shanghai.

The mathematical curriculum implemented in Turkey aims to improve not only students' self-efficacy perceptions, but also their confidence in their ability to deal with mathematics, in addition to other competencies that are dealt with in any other learning domain (MEB, 2009). In a study on fifth grade students, it was emphasized that students whose mathematics self-efficacy levels were high not only had faith

in their ability to succeed in mathematics, but also exhibited higher participation in learning activities (Öztürk & Şahin, 2015). In this respect, it is important that students' confidence in their mathematics skills be developed and supported through in-class activities and that teachers adopt motivational approaches to aid students in building such confidence.

Among student-level variables, it was observed in all three countries that students' mathematics self-efficacy increased as teacher support increased. When teachers are kind to their students, when they stand by their students in times of need, and when they have developed good communication bridges with them, their self-efficacy increases. As indicated in the EARGED (2005) report, for students in Turkey, the positive belief in teacher support is above the OECD average. In this respect, it is of great importance that teachers support their students, that they respond to their needs using proper channels of communication, and that schools support such behaviors.

One's attitude toward school is another factor that contributes to students' self-efficacy levels. Students who have a positive attitude toward school and who believe that school is important in preparing young individuals for adult life have higher mathematics self-efficacy levels. The literature on self-efficacy and attitude generally focuses on students' attitudes toward mathematics rather than on school itself, emphasizing the positive effects of having a positive attitude on success (Fennema & Sherman, 1978; Peker & Mirasyedioğulları, 2003; Shiraman, 2006; Yücel & Koç, 2011). In addition to the study results, considering the positive association between attitude and achievement, students should be supported in developing a positive attitude toward school. In order to achieve this, it is important that schools teach such knowledge and skills used in students' daily life.

A negative association was observed in all three countries between the variables *socio-cultural index* and *educational opportunities at home*, on the one hand, and *mathematics self-efficacy*, on the other. This means that students with a lower socio-cultural index and educational opportunities at home have lower mathematics self-efficacy levels. Regarding Turkey, the reason for this situation might be that families of students with higher socio-cultural level support their children more with private lessons, additional courses, and non-school mathematical courses, and thus have higher expectations for higher performance in mathematics, which in turn could lead to increased mathematics self-efficacy levels in students. However, the fact that all three countries display similar results requires a more profound analysis of the factors that might be affecting such result. Regarding the literature on socio-cultural index and self-efficacy levels, Taşdemir (2012) studied how students' places of residence and monthly family income affected how they perceived their own self-efficacy levels in mathematics. He suggests that there is no significant relationship between these variables. Ekici and Çevik (2008) suggested that there was no significant

differentiation in students' self-efficacy levels in biology based on their families' monthly income levels. In contrast, it was suggested that children of poor families believe that although they believe they have the sufficient skills, they also believe that they will not be able to fulfill their desires for advanced education due to economic barriers and thus avoid taking steps toward doing so (Kuzgun, 2003).

While pre-school education in China-Shanghai and Turkey were negatively associated with students' mathematics self-efficacy levels, it had a positive in Greece. For Greece, longer periods of preschool education were found to support students' self-efficacy levels in mathematics. In this respect, an analysis of the compatibility of the preschool mathematical curriculum in these countries might provide data supporting this result.

The variable *mathematical anxiety*, in turn, was negatively associated with students' mathematics self-efficacy scores in China-Shanghai and Greece and positively associated in Turkey. Unlike in China-Shanghai and Greece, the higher students' mathematical anxiety level was in Turkey, the higher their self-efficacy levels were. While Hackett and Betz (1989) suggested that higher anxiety levels led to lower self-efficacy, Cooper and Robinson (1991) suggested that there is a negative association between self-efficacy in mathematics and mathematical anxiety. Furthermore, Pajares and Kranzler (1995) also emphasized that a strong association exists between students' self-efficacy levels in mathematics and mathematical anxiety. In his international comparative study based on the 2003 PISA results, Yildirim (2011) suggested that there is a negative association between students' anxiety levels and self-efficacy levels in Japan, Finland, and Turkey. All of these studies support the result attained for China-Shanghai and Greece. For Turkey, the conclusion is the opposite. Individuals with higher self-efficacy strive harder to deal with problems encountered. For example, the time it took and the amount of effort made to solve problems on a math test were determined by students' self-efficacy levels (Pajares & Miller, 1997). A student's belief in his/her ability to cope with a task affected not only the amount of effort made, but also the level of anxiety experienced. Students with high levels of self-efficacy are more apt to use cognitive and metacognitive strategies and are more insistant when attempting to complete even hard or uninteresting academic tasks (Pajares, 1996, 2002; Pajares & Kranzler, 1995; Pajares & Miller, 1997; Pintrich & De Groot, 1990; Zimmerman, Bandura, & Martinez-Pons, 1992). Considering both the aforementioned and the fact that the educational system in Turkey is based on placing students into certain programs and areas, it might be suggested that successful students have both high level of anxiety and self-efficacy. In order to provide proof of this conclusion, a multi-regression model may be constructed to analyze the mediating effect of self-efficacy on Turkish students' mathematical literacy and anxiety levels.

The variable *interest in mathematics*, in turn, was negatively associated with mathematics self-efficacy only in China-Shanghai. Mathematics self-efficacy is suggested to be directly associated with motivation in mathematics courses (Levitt, 2001).

The literature on student level variables related to mathematics self-efficacy generally focuses on the variables of gender and academic success. In the literature, some studies emphasize that students' mathematics self-efficacy levels differ according to gender (Çakıroğlu & Işıksal, 2009; Öztürk & Şahin 2015; Pajares, 2005; Pajares & Graham, 1999) whereas others suggest that they do not differ according to gender (Akay & Boz, 2011; Pajares, 2005; Pajares & Graham, 1999; Yamaç, 2011). Studies on academic success emphasize that students' mathematics self-efficacy levels are a good indicator of their performance in mathematics (Malpass, O'Neil, & Hocevar, 1999; Pajares & Graham 1999). There are also studies suggesting that one's level of mathematics self-efficacy is positively affected by academic success in mathematics (Çelik, 2012; Dandy & Nettelbeck, 2002; Eshel & Kohavi, 2003; House, 2004; Yamaç, 2011; Zusho & Pintrich, 2003).

Regarding the association between the level of mathematics self-efficacy and school level variables, *class size* was not considered as a significant variable. However, the *ratio of mathematics teachers at school*, meaning the number of students per mathematics teacher, and *teacher's motivation* were considered significant variables in China-Shanghai. For Turkey, all three variables were considered to be significant. In Greece, the *ratio of mathematics teachers at school* was a significant variable.

Regarding the variable *class size*, which was significant only for Turkey, it had a near-zero positive association with self-efficacy levels. This means that there was a near-zero association between an increase in the students' numbers and self-efficacy levels. Studies on the relationship between class size and students' achievement, as opposed to mathematics self-efficacy, suggest that class size is a significant variable that affects students' achievement. While some studies (Boozer & Rouse, 2001; Hedges & Stock, 1983; McGiverin, Gilman, & Tillitski, 1989) suggest that lower class size has a positive contribution on achievement, some emphasize that although lower class size provides advantages for teachers and students, achievement cannot be increased effectively by simply decreasing class size (Hanushek 1999; Lockheed & Komenan, 1989; Molnar et al., 1999). Furthermore, it is also suggested that for students attending classes with lower size, there is lower probability to fail the class or to drop out of school and that there are more advantages for students in classes of smaller size (Hattie, 2002). Apart from academic achievement, it is emphasized that teachers have a more positive attitude toward teaching in smaller classes and that they better enjoy teaching and managing small classes (Shapson, Wright, Eason, & Fitzgerald, 1980). In lower class size conditions, students have better opportunities to

take responsibility in the classroom and teachers spend less time ensuring classroom discipline, and thus have more time to interact with students (Bourke, 1986). As a result, lower class size translates into students being more able to actively participate in the learning process without being lost in a crowded class. It is expected that students in classrooms that allow them to actively participate in the learning process will have higher self-efficacy levels.

In all three countries, there was a negative association between the *ratio of mathematics teachers* and self-efficacy. This means the higher the number of students per mathematics teacher at school, the lower the level of self-efficacy of students. While the effect was smaller in China-Shanghai and Turkey, it was comparatively higher in Greece. Studies on the relationship between teacher to student ratios and achievement suggest that there is a significant negative association between these two variables (Stern, 1989). In his study on teacher to student ratios, in which it is taken as an independent variable, Hanushek (1989) reviewed 152 articles, finding 27 to be significant (as cite in Tural, 2002). In the United States, while the teacher-student rate was 27 in 1955, it dropped to 17 in 1997, resulting in 15-18 students per teacher. Currently in Turkey, the ratio is 30 students per teacher (Tural, 2002). Considering the fact that students with higher self-efficacy have higher levels of achievement, it is expected that the variable *teacher to student ratio*, whose effect on student achievement cannot be neglected, make a contribution to increased student self-efficacy.

In China-Shanghai and Turkey, a positive association was found between the variables of teacher's morale and students' self-efficacy levels. Again, the rates were close in both countries. Although studies on students' self-efficacy in mathematics were reviewed, no study focusing on school level variables was found. Since teachers have a significant role in educational and learning processes, it is expected that teachers' increased morale have a positive effect on student achievement. Studies on the relationship between teacher's morale and achievement are as follows: (Briggs, 1986; Cook, 1979; Dennis, 1973; Willer, 1981). There are also studies on the relationship between teachers' morale and social development (Nidich, 1985; Nwankwo, 1979). In this respect, teacher's high morale could contribute to raising students with self-efficacy levels.

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