The Effect of Teacher and Student Characteristics on TIMSS 2011 Mathematics Achievement of Fourth-and Eighth-Grade Students in Turkey*

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Abstract

This study investigated effect of student- and school-level variables on mathematics achievement of fourth- and eighth-grade students using the Trends in International Mathematics and Science Study (TIMSS) 2011 data of Turkey. The common variables addressed in student and school questionnaires were compared. Due to nested structure of the TIMSS data, hierarchical linear modeling analysis was performed. According to findings of the study, for both grade levels, of all teacher-related variables, only school emphasis on academic success were discovered to have statistically significant impact on schools' mean mathematics achievements. Moreover, concerning student-level variables, being bullied at school, confidence in mathematics, being engaged in mathematics and parental involvement had statistically significant effect on students' mathematics achievement for both grade levels. It is considered that students that hold more positive perceptions of their school and have teachers that are willing to improve themselves in their career tend to have higher performance in TIMSS.

Keywords: Student characteristics • HLM • Mathematics achievement • TIMSS • Teacher characteristics

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Introduction

Many countries consider students' academic achievement to be a significant indicator of the quality of the education system. Therefore, studies have been undertaken to determine the inadequate aspects and constituents of the education system and amend them through decisions with respect to the discovery of the impartial instruments of measurement (Ministry of National Education-MoNE, 2010). As part of this process, within the last two decades, several countries have participated in international educational assessment studies to monitor their quality of education. An example is the Trends in International Mathematics and Science Study (TIMSS), which was first established in 1995 to collect data from fourth- and eighth-grade students every four years to determine the trends in mathematics and science achievement of these students at the international level.

According to the TIMSS report (Mullis, Martin, Foy & Arora, 2012), a significant percentage of Asian students achieved the advanced international benchmark level. Moreover, for more than a decade and a half, East Asian jurisdictions regularly hold the top positions with high performance against their Western competitors. Furthermore, there is a considerably large gap between the East and the West in terms of student achievement according to Program for International Student Assessment (PISA) 2012 and TIMSS reports (Jerrim, 2014).

As the case for the education ministries of several other countries, the Ministry of National Education (MoNE) in Turkey also uses TIMSS results to evaluate student achievement and compare the Turkish education system with that of other countries. Several researchers have also conducted research based on this data. For example, Büyüköztürk, Çakan, Tan and Atar (2014a) showed that Turkish students have difficulty keeping pace with their peers from other countries regarding mathematics achievement. For example, compared to the Asian pupils, Turkish students' performance is rather poor. Therefore, the reasons behind this poor performance should be examined in detail. There are several factors affecting students' mathematics achievement. In this regard, in this study, the effect of several characteristics and different experiences of students and teachers on the mathematics achievement of fourth- and eighth-grade students were investigated using the data from TIMSS 2011 for Turkey.

MoNE has a major responsibility and control over the whole structure of the educational system in Turkey. In 2005, MoNe introduced a new teaching program to be practiced across the country, which focuses on the student and his/her cognitive skills. However, contrary to the expectations, the new approach did not result in an increase in the academic achievement of students (Education & Science Workers' Union, 2010). In 2011, MoNE used TIMSS for the first time as a large-scale assessment tool to evaluate the outcomes of the curriculum change in 2005 for both fourth- and eighth-grade students. Therefore, it is considered that the results and implications of this study will greatly contribute to the literature. In this context, the findings regarding the differences between fourth- and eighth-grade students in Turkey, who participated in TIMSS 2011 will also help us make important inferences about the national education system (Büyüköztürk et al., 2014a).

Mathematics is one of the several subjects covered in TIMSS. It is necessary to learn mathematics in order to learn interdisciplinary areas such as science, technology and engineering. At the same time, mathematics is an important asset for a country for the innovation and creation of new scientific- technological professions (Ker, 2013). Mathematics achievement of students have been considered to be connected with a country's future economic well-being and competitive power against other countries. Thus, it is a common objective of the national policy makers and educators worldwide to understand and identify factors that have a significant and consistent relationship with mathematics achievement (Wagemaker, 2003). According to the results of TIMSS 2011, the Turkish students were behind their peers from other countries with Turkey ranking 35 among more than 50 countries in terms of the average mathematics score of the fourth-grade students (469). Furthermore, the percentage of Turkish students included in the advanced, high, intermediate and low benchmarks were 4, 17, 29, and 26, respectively with the remaining 24% not even being able to reach the low level. Concerning the eighth-grade students in Turkey, the average mathematics score was 452 and

Turkey ranked 24 among 42 countries. The percentage of Turkish students in the high, intermediate and low benchmarks were 13, 20 and 27, respectively. However, similar to the fourth-graders, a significant number of Turkish eighth-grade students (33%) did not even achieve the low level (Büyüköztürk et al., 2014b). These results demonstrate the low performance of Turkish students in mathematics and science.

In TIMSS, in addition to cognitive skills, certain educational and affective characteristics of students are surveyed. This means that the cross-sectional data obtained from TIMSS can be used to investigate the variables that play a role in student achievement at different grades in different years. The present study utilized the 2011 TIMSS data to examine the student- and school-level variables to explore their effect on the mathematics achievement of fourth- and eighth-grade students in Turkey. The common variables addressed in both fourth- and eighth-grade student and school questionnaires were compared. Student-related variables were being bullied at school, being engaged in mathematics, confidence in mathematics, enjoying learning mathematics, sense of belonging to school and parental involvement in student learning. The variables related to teachers consisted of confidence in teaching mathematics, teachers' working conditions, schools' emphasis on academic success, teacher career satisfaction, collaboration to improve teaching and instruction to engage students in learning.

The first student-level variable examined in this study was students confident in mathematics. In the literature, researchers (e.g. Arıkan, van de Vijver & Yagmur, 2016; Chen, 2014) have stated that self-confidence is positively related to mathematics success of students. According to the longitudinal study by Hannula, Maijala, and Pehkonen (2004), students' confidence in mathematics is the most important variable among students' mathematics-related attributes. It has also been recommended in the literature that enjoying learning mathematics and academic achievement are positively related (Güzeller, Eser & Aksu, 2016; Yavuz, Demirtaşlı, Yalçın & İlgün Dibek, 2017).

Being bullied at school is another variable affecting students' academic achievement. Olweus (1993) described the negative outcomes of this experience as follows, "a student is being bullied or victimized when he or she is exposed, repeatedly and over time, to negative actions on the part of one or more other students" (p. 9). The related literature supports this idea demonstrating that being bullied in school reduces student academic performance (e.g., Ponzo, 2013). Therefore, in this study, it was considered necessary to investigate the effect of bullying in the achievement of Turkish students.

Research into student engagement has mainly and historically concentrate on increasing achievement, a sense of belonging so that students remain in school (Taylor & Parsons, 2011). A positive relationship between students engaged in mathematics lessons and mathematics achievement (Park, 2005; Tavşancıl & Yalçın, 2015) has been found to increase students' sense of belonging to schools and other social institutions (Willms, 2003).

The concept that parental involvement has a positive impact on students' academic achievement is so heuristically attractive that society in general, and educators in particular, have thought about parental involvement an substantial component for the way for many problems in education (Fan & Chen, 2001). Most empirical evidence suggests that parental involvement is positively correlated with students' performance in school (Shute, Hansen, Underwood & Razzouk, 2011; Topor, Keane, Shelton & Calkins, 2010). However, a negative significant relation has been reported between parents' involvement in Turkish students learning and the mathematics achievement of these students (Tavşancıl & Yalçın, 2015).

It has been suggested in the literature that students' belonging to school and academic achievement are positively related (Appleton, Christenson & Furlong, 2008). Having been considered to be related to the motivation theory, individuals' belonging to a community has long been seen as a basic human need. Some studies have explained the sense of belonging to school with student engagement and participation (e.g., Rooser, Midgley & Urban, 1996). However, it was emphasized in the longitudinal study of Anderman (2003) that this sense of belonging loses its effect as the time passes. Since students' perceptions of their school are reflected on their sense of belonging

(Organisation for Economic Co-operation and Development- OECD, 2003), the findings of the study may have been affected by the exam-oriented education system in Turkey.

Confidence in teaching mathematics is one of the school-level variables addressed in the study. The role of teachers' confidence in students' achievement has been demonstrated in recent studies (Liang & Jea, 2015). Burton (2004, p. 360) defined the concept of confidence as "a label for a confluence of feelings relating to beliefs about the self, and about one's efficacy to act within a social setting, in this case the mathematics classroom". Graven (2004) theorized confidence not only as a consequence of learning but also as a process. Graven (2004) also suggested that confidence is associated with teachers' ability to reach resources, join in mathematical event, and consider themselves as qualified mathematics teachers with a confidence that is enough to consider the possibility of having much to learn.   Teachers' satisfaction with their career is another factor that positively affects students' mathematics achievement (e.g., Liang & Jea, 2015). In his literature review on teacher job satisfaction, Leithwood (2007) found a strong relationship between teacher satisfaction and motivation and commitment. Career satisfaction and motivation are two significant elements that have a crucial role in long-term growth in any education system. Their importance is equivalent to that of professional knowledge, instruction skills and reach to educational resources (Oloube, 2005). Dinham (1993) suggested that the most important factors affecting teachers' satisfaction with their career are intrinsic including students' achievement and positive attitudes towards learning, self-growth, positive relationships with students and peers, mastery of professional skills and the presence of a supportive environment.

Working conditions for teachers include the physical characteristics of the workplace, the psychological, cultural and educational characteristics of the work setting (Johnson, 2006). The conditions of work are significant in terms of teacher retention and also an substantial issue for students in relation to the continuity of teaching (Hirsch & Church, 2009). The working conditions of the teachers is closely correlated to the motivation of both teachers and students and in turn this affects student achievement (Marcondes, 1999).

In this study, school's emphasis on academic achievement was chosen as another school level variable since it can raise awareness of students' academic life and aims. In fact, it has been demonstrated that this variable is positively correlated with students' mathematics achievement (Tavşancıl & Yalçın, 2015). Therefore, it is considered necessary to examine the role of school's emphasis on academic success in relation to Turkish students.

The last school-level variable examined in this study was level of collaboration to improve teaching. In the literature, the importance of the collaboration to improve teaching for student achievement has been emphasized (McLaughlin & Talbert, 2006; Pang, 2006). The more the teachers cooperative, the more they are able to knowledgeable converse about methods, operations of teaching and learning, and therefore develop their instruction (Goddard, Goddard & Tschannen-Moran, 2007).

In brief, many studies have shown that the chosen variables are important determinants of student achievement. The review of the literature demonstrates that studies investigating both student- and school-level variables for eighth graders are limited in number, especially in Turkey (Tavşancıl & Yalçın, 2015). Therefore, the current study aimed to fill a gap in the literature. In addition, to our knowledge, no studies have taken into consideration the common variables for fourth-grade and eighth-grade students or interaction between these variables to predict mathematics success in the context of a large-scale dataset that would allow results to be generalized to the entire Turkey. In accordance with the purpose of the study, the following research questions were formulated: (i) Does mathematics achievement of fourth- and eighth-grade students differ according to the schools?; (ii) Which characteristics or experiences of students are related to their mathematics achievement?; (iii) Which characteristics of teachers are related to students' mathematics achievement?; (iv) Which school features that clarify the significant difference between the mathematics achievements of the fourth- and eighth-grade students have a significant relation with the achievements of the fourth- and eighth-grade students that participated in TIMSS 2011?

Method

Sample

In the selection of the sample, a two-stage stratified cluster sampling design was used, in which the schools and classrooms were selected in the first and second stages in proportional to their sizes. The population and sample that participated in the TIMSS 2011 in Turkey were as follows (Joncas, 2012):

Table 1. *Population and Sample*

Grade	Population		Sample	
	Schools	Students	Schools	Students
4th grade	26247	1 301 460	257	7479
8th grade	17621	1198697	239	6928

Instruments

The data were retrieved from the official web site of TIMSS (http://timssandpirls.bc.edu/). The common variables measured in both grade levels were obtained from two questionnaires, one for students and the other for teachers. In addition, all the plausible values were used as the true representation of mathematics scores of the students. These scores were obtained from the mathematics achievement test. In TIMSS 2011, mathematics achievement test has two main domains, content and cognitive domain. The former differs between the grade levels while the latter (knowing, applying and reasoning) are the same for both grades. Specifically, the mathematics achievement test for fourth-grade students comprises items related to number, geometric shapes and data display while for eighth-grade students, the items contained numbers, algebra, geometry, data and chance.

Data Analysis

The analysis was performed after the indices of the corresponding variables were created. At this point, since the variables parental involvement and students' belonging to school had no index values, the national indices for all variables were computed to validate the results obtained from this study. An index formula was used to generate all indices (see, OECD, 2014, p. 352)

Two-level hierarchical linear modeling (HLM) was performed to analyze the data. The HLM analysis is used for analyzing data in a clustered or nested structure. With hierarchical linear models, each level is formally represented by its own sub-model. It is possible to test hypotheses about relations occurring at each level and across levels and also to examine the variability at each level (Raudenbush & Bryk, 2002). Moreover, considering the independence and homoscedasticity assumptions, the HLM analysis allows determining standard errors and thus provides more reliable results. In this study, the following four models were developed to analyze the data for both grade levels:

Random effects one way ANOVA model. Concerning the first research question, random effects one way ANOVA models were developed for both the fourth- and eighth-grade students to determine whether there was a difference in the mathematics achievement of the schools that join in TIMSS 2011.

Means-as-outcomes model. To determine which of the school-level variables explained the variability in TIMSS mathematics scores, means as outcomes models were developed for students from both grades. In this regard, to address the second research question of this study, the effects of school-level variables on students mathematics achievements were analyzed using these models.

Random coefficient regression model. Two models were developed for students in both grades to address the third research question of the current study by investigating the student-level

variables and clarify the individual differences in the variability of students' mathematics achievement scores.

Intercepts- and slopes-as–outcomes model. This model was the combination of all the models developed previously and aimed to simultaneously examine the influence of student- and school level variables. In this process, only the variables that had a statistically significant effect on students' mathematics achievement were added to the intercepts and slopes-as-outcomes model for fourth- and eighth-grade students to address the fourth research question of this study.

After the analyses were conducted, the assumptions of HLM were tested using HLM 7 and SPSS-20 programs and it was found that none of the assumptions were violated.

Results

Random Effects One-Way ANOVA

According to the results of this analysis, the mathematics scores of the fourth-grade students was significantly varied according to schools (χ^2_{230}=4005.25, p<.05) with the mean score being 475.52. The variability within the school and between the schools were estimated to be 5794.04 and 3463.81, respectively. In this regard, intraclass correlation was calculated as 0.37, which indicates that 37% of the variability in the mathematics scores of the fourth-grade students was explained by the mean mathematics achievement of the school.

Concerning the results obtained from the analysis of the random effects one-way ANOVA model developed for the eighth-grade students, the mathematics achievement scores eighth also significantly differed between the schools (χ^2_{218}=3073.82, p<.05) with the mean being calculated as 450.79. Within-school variability and between-school variability were estimated as 8403.57 and 3928.74, respectively. The intraclass correlation was calculated as 0.32, which means that 32% of variability in mathematics scores resulted from the differences in the mean mathematics achievement of schools.

Means-as-Outcomes Models

The results obtained from the analysis means-as-outcomes models are presented in Table 2.

Table 2. *Results Obtained from Analysis of Means as Outcomes Model*

Fixed Effect	Grade	Coefficient	S.E	t-ratio	df	Effect
Average mathematics achievement, γ_{00}	4th	475.57	3.56	133.77*	224	-
	8th	450.88	3.87	116.43*	212	-
Confidence in teaching Mathematics, γ_{01}	4th	11.98	9.02	1.33	224	.23
	8th	4.22	2.78	1.52	212	.08
Teacher working conditions, γ_{02}	4th	7.45	3.90	1.92	224	.14
	8th	1.19	4.28	.28	212	.02
Emphasis on academic success, γ_{03}	4th	20.10	6.08	3.31*	224	.38
	8th	35.03	5.31	6.60*	212	.65
Teacher career satisfaction, γ_{04}	4th	12.22	6.08	2.01*	224	.23
	8th	3.68	5.64	.65	212	.07
Collaboration to improving teaching, γ_{05}	4th	7.67	3.70	2.07*	224	.15
	8th	3.96	5.42	.73	212	.07

Instruction to engage students, γ_{06}	4th	7.25	4.80	1.51	224	.14
	8th	0.45	6.54	.07	212	.008
Random Effect		sd	variance	d.f.	χ^2	
School level, u0	4th	52.43	2748.35	224	3136.58*	
	8th	53.68	2881.88	212	2267.37*	
level-1, r	4th	76.12	5794.46			
	8th	91.67	8403.60			

*Variable was statistically significant at *p*<.05

According to these results, among the school-level variables, the variables teacher career satisfaction, schools' emphasis on academic achievement and collaboration to improve teaching were found to have a statistically significant positive effect on the success of the fourth-grade students. On the other hand, for the eighth-grade students, except for school's emphasis on academic success, none of these variables were found to have a significantly positive impact. Furthermore, school's emphasis on academic success had a statistically significant negative impact on the mathematics success of the eighth-grade students' ($\gamma 03$=-35.03, *p*<.05). The school-level variables that did not have any significant effect on the mathematics achievement of the fourth- and eighth-grade students were removed from the models. To explain the variance of the remaining variables, their effects were controlled and according to the result, the three significant variables explained 21% of variability in the mathematics scores of the fourth-grade students while one significant variable explained 27% of the variability in the eighth-grade students' mathematics scores.

A large sample size may yield a statistically significant relationship (Fishman and Galguera, 2003). Therefore, in this study, when the practical significance of the variables was analyzed, the fourth-grade students and eighth-grade students were taken into consideration separately.

School's emphasis on academic success was found to have the highest effect on the mathematics success of both fourth- and eighth-grade students. That is, the effect size of this variable showed that an increase of one standard deviation in this variable would result in an increase of .38 and .65 standard deviation in the mean mathematics achievement of the fourth- eighth-grade students, respectively. Although among the school-level variables, confidence in teaching mathematics, teachers' working conditions and instruction to engage students in learning did not have a statistically significant impact on the mathematics success of the fourth-grade students, they were found to have a practical significance.

Random Coefficient Regression Model

The results of the random coefficient regression models were presented in Table 3.

Table 3. *Results Obtained from Analysis of Random-Coefficients Regression Model*

Fixed Effect	Grade	Coefficient	S.E	t-ratio	df	Effect size
Average mathematics achievement, γ_{00}	4th	475.50	4.01	118.51*	230	-
	8th	450.80	4.49	100.34*	218	-
Being bullied at school, γ_{10}	4th	-11.15	1.29	-8.66*	46	-.19
	8th	-6.86	1.46	-4.69*	42	-.11
Students' like learning mathematics, γ_{20}	4th	6.94	2.09	3.32*	47	.12
	8th	2.36	1.59	1.48	1386	.04

Students' confident in mathematics, γ_{30}	4th	28.62	1.50	19.08*	50	.48
	8th	62.76	2.38	-26.32*	6183	.99
Students' engagement in mathematics, γ_{40}	4th	7.24	1.54	4.70*	268	.12
	8th	6.46	2.01	-3.22*	91	.10
Students' belonging to school, γ_{50}	4th	7.65	2.55	3.00*	33	.13
	8th	4.04	2.23	1.81	18	.06
Parental involvement, γ_{60}	4th	-8.55	1.66	-5.16*	87	-.14
	8th	-8.18	1.23	-6.67*	451	-.13

Random Effect		sd	Variance	d.f.	$\chi 2$
INTRCPT1, u0	4th	59.26	3511.94	230	4994.08*
	8th	63.38	4017.32	218	4172.11*
level-1, r	4th	68.17	4646.73		
	8th	78.69	6191.78		

*Variable was statistically significant at *p*<.05

At student-level, the corresponding p values of all variables indicated that the effect of the variables on mathematics achievement were statistically significant for the fourth-grade students. Adding these variables into student-level HLM analysis reduced within-school variability from 5794.04 to 4646.73, which indicates that these variables explained 19.8% of within school variability in the mathematics scores of the fourth-grade students.

Concerning the results for the eighth-grade students, the effects of the variables being bullied at school, being engaged in mathematics, confidence in mathematics and parental involvement were found to have significant effect. The remaining variables were removed from the model. At the student-level, there was also a negative significant relationship between being bullied at school and the mathematics success of the eighth-grade students (γ_{10}=-6.86, *p*<.05). Similarly, parental involvement was found to be negatively correlated with eighth-grade students' achievement (γ_{60}=-8.18, *p*<.05). On the other hand, a positive relationship was found between eighth-grade students' engagement in mathematics and their achievement ($\gamma 40$=6.46, *p*<.05). Another positive relationship was found between these students' confidence in mathematics and their achievement ($\gamma 30$ =62.76, *p*<.05). Adding these variables into student-level reduced within-school variability from 8403.57 to 6191.78, which indicates that these variables explain 26 % of within-school variability in students' mathematics scores.

Considering the effect size of all variables, the fourth-grade students' like and students engaged in mathematics were found to have the lowest effect on their mathematics success. Specifically, an increase of one standard deviation in these variables would result in an increase of .12 standard deviation in their mean scores. On the other hand, the fourth-grade students' confidence in mathematics had the highest impact on their mathematics achievement. More precisely, an increase of one standard deviation in this variable would increase the mean scores by .48 standard deviation. Concerning the results related to the practical significance of the effect of the variables on the mathematics success of the eighth-grade students, their like learning mathematics was found to have the lowest effect on their achievement. That is, an increase of one standard deviation in this variable would result in an increase of .04 standard deviation in the mean achievement of these students. On the other hand, the eighth-grade students' confidence in mathematics was found to have the highest effect on their mathematics achievement. Demonstrating that an increase of one standard deviation would provide an increase of .99 standard deviation in their mean scores.

Intercepts- and Slopes-as-Outcomes Model

When the significant student- and school-level variables were added to the same model, two of the school-level variables, teacher career satisfaction and collaboration to improve teaching, were no longer significant for the fourth-grade students as shown in Table 4.

Table 4. *Results Obtained from Analysis of Intercepts-and-Slopes-as-Outcomes Model*

Fixed Effect	Grade	Coefficient	S.E	t-ratio	d.f.	Effect Size
Average school mean achievement, γ_{00}	4th	475.51	3.63	131.06*	227	-
	8th	450.86	3.91	115.35*	217	-
School emphasis on academic success, γ_{01}	4th	26.14	5.64	4.63*	227	.49
	8th	36.45	5.35	6.81*	217	.67
Teacher career satisfaction, γ_{02}	4th	11.63	6.14	1.90	227	.22
	8th	-	-	-	-	-
Collaboration to improving teaching, γ_{03}	4th	5.82	3.65	1.59	227	.11
	8th	-	-	-	-	-
Being bullied at school, γ_{10}	4th	-11.00	1.25	-8.78*	52	-.21
	8th	-6.38	1.34	-4.76*	86	-.12
Students' like learning Mathematics, γ_{20}	4th	6.67	2.14	3.12*	38	.13
	8th	-	-	-	-	-
Students' confident in mathematics, γ_{30}	4th	28.83	1.47	19.55*	49	.54
	8th	61.05	1.88	-32.49*	2251	1.12
Students' engagement in mathematics, γ_{40}	4th	7.40	1.52	4.88*	222	.14
	8th	4.51	1.74	2.58*	395	.08
Students' belonging to school, γ_{50}	4th	7.98	2.59	3.08*	29	.15
	8th	-	-	-	-	-
Parental involvement, γ_{60}	4th	-8.87	1.70	-5.22*	102	-.17
	8th	-9.12	1.26	-7.22*	174	-.17

Random Effect		sd	Variance	d.f.	$\chi 2$	
INTRCPT1, u0	4th	53.59	2871.78	227	4024.86*	
	8th	54.32	2950.60	217	3130.56*	
level-1, r	4th	68.08	463.52			
	8th	78.64	6183.73			

*Variable was statistically significant at *p*<.05

Additionally, all the student-level variables were still significant predictors of the fourth grade students' mathematics achievement. Adding these variables to student-level reduced between the school variability from 3511.94 to 2871.78, which indicates that these variables explained 18% of within school variability in the students' mathematics scores. Concerning the results for the eighth-grade students, the effects of the student-level variables being bullied at school, being engaged in mathematics, confidence in mathematics and parental involvement were significant on the achievement of the eighth-grade students. At the student-level, there was also a negative significant relationship between eighth-grade students' being bullied at school and their mathematics achievement ($\gamma 10$=-6.86, *p*<.05). Similarly, parental involvement was found to be negatively correlated with the

eighth-grade students' achievement ($\gamma 60$=-8.18, p<.05). On the other hand, a positive relationship was found between these students' engagement in mathematics and their achievement ($\gamma 40$=6.46, p<.05) as well as between their confidence in mathematics and achievement ($\gamma 30$ =62.76, p<.05). Adding these variables to the student level reduced the within-school variability from 4017.32 to 2950.60, indicating that these variables accounted for 26% of the within-school variability in the students' mathematics scores.

When the practical significance of the effects of the student-level variables was considered for both grades, it was found that students' confidence in mathematics had the highest effect. Specifically, the effect size of this variable showed that an increase of one standard deviation in this variable would increase of the standard deviation of mathematics scores by .54 and 1.12 for fourth- and eighth-grade students, respectively. On the other hand, of all the student-level variables, enjoying learning mathematics had the lowest effect on the fourth-grade students' mathematics achievement and being engaged in mathematics had the lowest effect on the eighth-grade students' achievement.

Discussion

In this study, the effects of student-level variables and school-level variables on the mathematics achievement of the fourth- and eighth-grade students in Turkey were examined. Parental involvement and being bullied at school had a negative effect on both fourth- and eighth-grade students' mathematics achievement. In addition, schools' emphasis on academic success, students' confidence in mathematics and students engaged in mathematics were found to be highly important for promoting mathematics achievement in both grades. The findings also showed that student-level variables had a higher impact for both grades than the school-level variables. Another important finding of the study was that among the school level variables, only collaboration to improve teaching and school's emphasis on academic success had a significant effect on the fourth- and eighth-grade students' mathematics achievement.

Studies in the related literature have reported similar results. For example, researchers have found that being bullied in school reduces student performance (Ponzo, 2013), which is expected considering the negative outcomes of this experience for both academic and social lives of students (Cowie, 2013). According to a meta-analysis based on research with students aged between 7 and 14 (Hawker & Boulton, 2000), regardless of the students' age and ethnicity, being bullied creates several risk factors and outcomes for these students. The results of cross-sectional studies have also shown that students being bullied result in these students creating a negative self-image. Children who experience bullying in school develop negative attitudes towards the school, teachers and their classmates (Lai, Ye & Chang, 2008). In this sense, teachers, administrators and policy-makers should consider the crucial importance of identifying and taking action to prevent bullying in all grades.

In several studies (e.g., Shute et al., 2011; Topor et al., 2010), parental involvement has been found correlated with students' achievement. However, as in this study, this effect has been reported to be negative in other studies conducted with Turkish students (e.g., Tavşancıl & Yalçın, 2015) and South African students (Wang, Osterlind &Bergin, 2011). It should be noted that in this study, parental involvement was assessed according to students' responses in TIMSS. Therefore, students' perceptions about their families' involvement may play a role in this finding. As reported by Kilic and Askin (2013), the Turkish and Singaporean students had lower academic performance, which can be attributed to the families in these countries tending to be strict about checking their children's homework on a daily basis. On the other hand, the students from Republic of Korea and Chinese Taipi who were not frequently monitored by their parents were reported to have a higher performance. However, this result can also be due to the different understanding of the concept of parental involvement in different cultures. According to Erdogan and Demirkasımoğlu (2010), Turkish families consider parental involvement solely as participating in meetings organized by schools and obtaining information and recommendations from teachers about their children. According to the longitudinal study by Hoge, Smit, and Crist (1997), parents' high expectations have a higher positive effect on students' achievement than parents' interest in students' grades, involvement in school and good

communication with their children. Since in this study, parental involvement did not include parental expectations about student achievement, the negative relationship between parental involvement and mathematics achievement can be interpreted as being meaningful. On the other hand, the reason why parental involvement did not have a positive effect on students' academic success in this study can be due to the generally lower socioeconomic background of Turkish families. For example, according to the TIMSS 2011 data on eighth-grade students (Büyüköztürk et al., 2014a), while the percent of students from the lowest socioeconomic level was 59 in Turkey, the percent of Korean students with high performance in TIMSS was 32. Hill and Taylor (2004, p. 162) explained this as follows, "parents from lower socioeconomic backgrounds face many more barriers to involvement, including nonflexible work schedules, lack of resources, transportation problems, and stress due to residing in disadvantaged neighborhoods." In the literature, parental involvement may be considered as a remedy for many problems in education (Fan & Chen, 2001). For example, in the meta-analysis of Jeynes (2012), parental involvement was found to have a high correlation with academic success. Therefore, the factors affecting this finding should be investigated in a further study focusing on parents' involvement with students coming from different socioeconomic backgrounds.

In this study, similar results were obtained from fourth- and eighth-grade students in terms of the positive relationship between being engaged in mathematics and mathematics achievement. This finding is consistent with those reported in different countries (Tavşancıl & Yalçın, 2015; Zhu & Leung, 2010). Therefore, the positive effect of this variable on mathematics achievement is expected. From this point of view, it can be stated that students' engagement has an important role in students' academic achievement in general (Park, 2005) and mathematics achievement in particular.

In this study, students' confidence in mathematics was found to be positively related with their mathematics success. This is consistent with the results reported by previous research (e.g. Chen 2014). Considering the positive outcomes of confidence in academic achievement (e.g., Al-Hebaish, 2012), it is not surprising that in a subject like mathematics, confidence has an important role in increasing achievement. According to Hannula et al. (2004)'s longitudinal study, self-confidence in mathematics is the most important variable among the students' beliefs concerning mathematics. Since students' beliefs about mathematics have an impact on their mathematics achievement, this finding supports the importance of self-confidence for the fourth- and eighth-grade students in Turkey.

According to the findings of this study, the eighth-grade students' belonging to school had no significant impact on their mathematics performance; however, it was significant for fourth-grade students. In the literature, a positive relationship has been reported between this variable and school and academic achievement (Appleton et al., 2008). This can be explained by the results of earlier studies that the effect of school belonging decreases by age (Bernard, 2004) and loses its impact over time (Anderman, 2003). Since school belonging refers to students' perceptions about their school (OECD, 2003), the finding of the present study may have been affect by the exam-oriented education system in Turkey, where all eighth-grade students have to take a test called the Placement Test for Secondary Education in order to continue their education. The compelling preparation for this exam negatively affects these students' perception towards school resulting in a decrease in their sense of school belonging compared to the fourth-grade students. Moreover, the mean mathematics score of the eighth-grade students in Turkey were found to be considerably lower than those of the fourth-grade students. Similarly, Sarı (2012) reported a significant difference between low and high achieving students in terms of school belonging. In this sense, the lower academic achievement of the Turkish students may be another reason for their less positive perceptions about school belonging.

Schools' emphasis on academic achievement was also found to have a positive effect on student success since it helps students develop positive attitudes concerning school. It also raises students' awareness about their academic life and aims. Similar to the previous TIMSS, a positive significant relationship was found between schools' emphasis on academic success and students' actual mathematics achievement (Tavşancıl & Yalçın, 2015).

The importance of teachers' collaboration to improve teaching for student achievement has been previously emphasized in the related studies (McLaughlin & Talbert, 2006; Pang, 2006). In this study, this variable did not have a significantly positive impact on the mathematics performance of the eighth-grade students whereas its effect was significant for fourth-grade students. Similar results have been reported in the literature (e.g., Thomson, Hillman &Wernert, 2012). This may have resulted from the fact that in Turkey, in the fourth grade, mathematics is taught by the class teachers whereas in the eighth grade, subject teachers are responsible for teaching mathematics. Therefore, the level and characteristics of teachers' collaboration tend to change over time. On the other hand, the OECD Teaching and Learning International Survey (TALIS) data indicated that Turkish teachers' collaboration rate was lower than that of many participating countries (OECD, 2009) and therefore, it may be the reason why students' achievement is not significantly affected by teachers' collaboration.

In this study, teachers' confidence in teaching mathematics was found to have no significant effect on student success. However, in the literature, some research has revealed that teachers' confidence in teaching mathematics increased students' achievement (Liang & Jea, 2015). The reason why in this study confidence in teaching mathematics did not have a significant effect on successs may be due to different characteristics of the Turkish mathematics teachers such as their anxiety about teaching, self-efficacy, practices, earlier beliefs and experiences. In addition, teachers' collaboration with others has a positive effect on their level of confidence in teaching (OECD, 2009). This was also supported by Aslan (2015), who based on TALIS data concluded that teachers in South Korea where academic achievement level is higher than most OECD countries exhibited much better professional collaboration than Turkish teachers.

Teachers' career satisfaction was another variable with no significant effect on eighth-grade students' mathematics achievement. Similar findings have been reported for teachers in England, where a higher level of career satisfaction was not found associated with increased pupil achievement (Sturman, Burge, Cook &Weaving, 2012). However, there is also research that showed that career satisfaction was positively related to mathematics achievement (Liang & Jea, 2015; Yildirim & Demir-Bilican, 2014). The TALIS data also indicated that teachers' career satisfaction was highly correlated with their professional collaboration with their colleagues (OECD, 2009). According to Burns and Darling-Hammond (2014), the individual and collective capabilities of teachers are improved through participation in collaborative activities since such activities increase teachers' self-confidence about teaching and managing the class as well as helping them take greater pleasure from their work. Taking into consideration Turkish teachers' lower levels of collaboration and career satisfaction compared to OECD countries, the findings of the presents study were expected.

Conclusion

This study identified several implications for Turkish students' mathematics achievement. In general, it seemed that the student-level variables had a more important role than teacher-level variables for both fourth- and eighth-grade students. Taken together, the findings suggest that investing in students and enhancing their affective factors would be beneficial to students' achievement. Students that hold more positive perceptions of their school and have teachers that are willing to improve themselves in their career tend to have a higher performance in TIMSS. Moreover, the results of this study also have implications for teacher educators. Developing teacher education and their features should be considered by education stakeholders.

Being limited to the student- and school-level variables, this study lacks information regarding the effects of other important variables on mathematics achievement. In this sense, further research should be undertaken to investigate more variables to provide an insight into these students' affective factors. In addition, the sample of this study was limited to Turkish students. Future research can use samples from different countries. Furthermore, since in TIMSS, the samples are formed by selecting one class from each school, the effect of class-level variables could not be investigated. In future work, class-level variables can be explored and three-level HLM analysis can be performed.

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