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Research Article

The effect of student and school characteristics on TIMSS 2015 science and mathematics achievement: The case of Türkiye

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In this study, the effects of some student (e.g., gender, bullying, etc.) and school variables (e.g., emphasis on academic achievement, clarity of teaching, etc.) on the TIMSS 2015 science and mathematics achievement of eighth grade students in Türkiye were examined by controlling for the socioeconomic status of the students at the student and school level. The analyses were performed using the multilevel modelling method and the HLM8 package program. The findings show that school variables account for 34% of the variability in the TIMSS 2015 science achievement of eight grade students, while student variables account for 66%. Similar to this, school variables account for 35% of the variability in these students' mathematics achievement and student variables for 65% of it. The socioeconomic status of the school at the school level and students' confidence in learning the lesson at the student level are the two variables that have the strongest effects on students' achievement in science and mathematics. According to the results, other variables that have a significant effect on students' achievement in both science and mathematics at the school level are the clarity of teaching, the emphasis on academic achievement, and the school bullying level. Furthermore, school discipline problems have an effect on students' mathematics achievement. However, school resources and teacher qualifications do not have a significant effect on student achievement. Home educational resources and bullying among students are two important variables that effect how well students do in science and mathematics. The effect of gender and value learning the lesson on science achievement was significant, whereas the effect on mathematics achievement was not. The effect of like learning lesson on student achievement is significant only for mathematics.

Keywords: TIMSS; Science achievement; Mathematics achievement; Multilevel modelling

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1. Introduction

Developing human capital in STEM fields (science, technology, engineering, and mathematics) is essential for a country's future economic success. Consequently, there is an increasing need worldwide to understand science and mathematics education. It is crucial to identify the student and school variables that influence science and mathematics achievement for the development and

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maintenance of excellent and equitable educational systems. As stated by Tyack & Cuban (1995, pp. 133),

> Rather than starting from scratch in reinventing schools, it makes most sense to us to graft thoughtful reforms on to what is healthy in the present system…

Since the Coleman report, researchers have tried to figure out if the success of some countries on international tests is due to differences like students' socioeconomic status (SES), cultural factors, or if the school systems play a role (Woessmann, 2016). TIMSS (Trends in International Mathematics and Science Study) is an excellent resource for assessing the efficacy of science and mathematics education (Mullis & Martin, 2017).TIMSS collects data on how participating countries perform and improve science and mathematics learning. TIMSS gives data on how well students are doing in school and on effective ways to teach. This information can be used to develop and improve educational programs (Hooper et al., 2013). In particular, the literature on effective schools and international achievement assessment studies like TIMSS, Programme for International Student Assessment (PISA), and the Progress in International Reading Literacy Study (PIRLS), as well as many other educational studies, showed that different student and school factors affect how well students do in science, mathematics, and reading (Martin et al., 2000; Martin & Mullis, 2013; Mullis et al., 2020). The first TIMSS assessment was carried out in 1995. Türkiye did not participated in either the 1995 or 2003 TIMSS assessments. Türkiye participated in the TIMSS assessments in 1999 and 2007 only at the eighth grade level, and in 2011 and 2015 at both grade levels. Türkiye scored lower than the international average in both of these assessments.

In the TIMSS assessment, students are divided into categories, which are expressed as proficiency levels, according to their scores; that is, what they can do in the lesson. Proficiency levels were determined as advanced, upper, intermediate, and lower levels. In the TIMSS 2015 assessment, 43-54% of students achieved advanced proficiency in Singapore, Taiwan, and Korea, but 10% or less of students achieved this level in 30 out of 39 countries. On average, 84% of eighth-grade students in Turkiye and other countries achieved a basic level of mathematics achievement. The highest percentages of students with advanced proficiency in science achievement are found in Singapore (42%), Taiwan (27%), and Japan (24%), whereas less than 10% of students in 27 out of 39 nations have achieved this level (Martin et al., 2016a). In their report on the TIMSS 2015 Türkiye data, Yücel and Karadağ (2016) stated that the mathematics achievement average of advanced students in Türkiye is the same as the average of intermediate level students in the top five most successful countries. Furthermore, according to the difference in mathematics scores (345) between the most successful and unsuccessful students in Türkiye, Türkiye is the country with the worst achievement disparities in the world. Türkiye is the 14th worst country in science in terms of the difference in scores (316) between the most and least successful students.

According to TIMSS 2015 results, the success rates of students whose schools are not safe and orderly are much lower than those of students whose schools are safe and orderly. With the rise of cyberbullying, there is evidence that bullying at school is getting worse, which hurts students' academic performance (Martin et al., 2016a; Mullis et al., 2016). It is possible that an effective school requires a safe and orderly environment, and that schools with significant disciplinary problems cannot improve student achievement. When teachers and students fear for their safety, it is difficult for them to concentrate on the lessons (Martin et al., 2000).

Another school environment factor, the quality and quantity of school resources, also plays a significant role in determining the quality of classroom teaching (Mullis & Martin, 2017). Some studies indicate that the general availability of school resources, such as general resources and science and mathematics lesson-specific resources, influences student achievement (Mohammadpour et al., 2015; Schreiber, 2002; Stanco, 2012). However, the relationship between resources and achievement is complex (Greenwald et al., 1996). First, the school may have a more advantageous student population due to its location or socioeconomically. Second, the school system can invest more money in facilities, teacher salaries, equipment, and supplies. As a result, it is likely that the most successful schools will have more students from higher-income families and better resources (Mullis et al., 2012). The impact of a school's resource level on student progress remains a matter of debate (Greenwald et al., 1996; Hanushek, 1986, 1997; Hedges et al., 1994; Wößmann, 2003). In a series of meta-analysis studies, Eric Hanushek, Larry Hedges, and their colleagues, perhaps the most well-known participants in the debate, gave different ideas about how school resources affect how well students learn (Ehrenberg et al., 2001).

The home background of students attending a school may be closely related to the learning environment, two of which reinforce each other and are strongly linked to academic achievement. Students whose homes encourage learning are also expected to have better attitudes about learning and maybe be more disciplined (Lay & Chandrasegaran, 2016). Since the Coleman report, there has been a great deal of interest in the relationship between socioeconomic status and academic performance (Caponera & Losito, 2016; Ersan & Rodriguez, 2020; Gustafsson et al., 2018; Martin et al., 2013; Mullis & Martin, 2017; Rumberger & Palardy, 2004; Sirin, 2005). Mohammadpour and Abdul Ghafar (2014) modelled the mathematics achievement of eighth grade students as a function of intra-school, inter-school, and inter-country differences using data from 48 countries that participated in the TIMSS 2007 assessment. The results indicated that at the country level SES is the most influential factor in determining the national mathematics mean.

The present study is expected to contribute to the development and improvement of learning models by identifying student and school level variables that influence eighth graders' TIMSS 2015 science and mathematics achievement. There are numerous mathematics focused studies in the literature. The situation is not different in Türkiye. Turkish students perform worse, especially in mathematics, on international assessments. So, this study is considered important because it lets us compare and evaluate student and school variables for science and mathematics lessons at the same time.

In educational research, the socioeconomic status of the students is generally used to control selection bias (Blömeke et al., 2016; Nilsen et al., 2016). In the present study, variables of socioeconomic status (student's SES and school's socioeconomic status) were used as student and school level control variables to ensure that all students in each school had an equivalent home background and all schools had an equivalent average home background (Martin et al. 2013). The independent variables in the study were classified into five categories: student characteristics, affective and behavioral characteristics; school climate; teacher preparation and clarity of teaching; school resources; and school safety. The study's research questions are classified under eight subheadings.

RQ 1) Does the achievement of eighth grade students in science and mathematics on the TIMSS 2015 assessment vary from school to school?

RQ 2) How effective are the student model variables (gender, home educational resources, like learning lesson, confidence in learning the lesson, value learning the lesson, engagement in lesson, and student bullying) on the TIMSS 2015 science and mathematics achievement of eighth graders when the home educational resources variable is controlled?

RQ 3) How effective are the teacher preparation and clarity of teaching[2] model variables (teaching experience, education level, major study area, professional development hours, and clarity of teaching) on the TIMSS 2015 science and mathematics achievement of eighth graders when the home educational resources variable is controlled?

RQ 4) How effective are the school climate model variables (emphasis on academic achievement, job satisfaction) on TIMSS 2015 science and mathematics achievement of eighth graders when the home educational resources variable is controlled?

2 For the engagement scale in TIMSS, the students were evaluated according to their degree of agreement with ten statements (it is easy to understand my teacher, my teacher is good at explaining the lesson, my teacher tells me how to do better when I make a mistake, etc.).The clarity of teaching variable, which is calculated by averaging the students' scores on this scale at the school level, expresses how clearly the teacher conveys the curriculum to the student (Martin & Mullis, 2013; Scherer & Gustafsson, 2015). This variable is also known as teaching quality or teaching effectiveness in various studies.

RQ 5) How effective are the school resources model variables (problems with school structure and resources; inadequacy of resources affecting teaching) on the TIMSS 2015 science and mathematics achievement of eighth grade students when the home educational resources variable is controlled?

RQ 6) How effective are the school safety model variables (safe and orderly school, school discipline problems, school bullying level) on eighth grade students' TIMSS 2015 science and mathematics achievement when the home educational resources variable is controlled?

RQ 7) How effective are the home educational resources variable and the socioeconomic status of the school variable together on the TIMSS 2015 science and mathematics achievement of eighth grade students?

RQ 8) Which student and school variables are effective on TIMSS 2015 science and mathematics achievement of eighth grade students when the home educational resources variable and the socioeconomic status of the school variable are controlled?

2. Method

2.1. Sample

TIMSS employs a stratified random sampling design with two stages. Initially, a sample of schools is selected. In the second stage, all students in one or more classes are selected from each sampled school (LaRoche et al., 2016). In this regard, the study's population includes 1.187.893 eighth graders in Türkiye. The sample consists of 6079 students selected from the population using random sampling approach. In this sample, there are 2943 female students and 3136 male students. 218 schools participated in this assessment. In present study, the listwise elimination method was used because the missing data rate did not exceed approximately 5% and a sufficient sample size was provided (Enders, 2010; Garson, 2019). After removing the missing data from the dataset, the sample size of the second level for science, which is the number of schools (N), decreased to 210, and the sample size of the first level, the number of students (n), decreased to 5726. For mathematics, the number of schools (N) decreased to 213 and the number of students (n) decreased to 5819.

In the study, student level variables were weighted with TOTWGT (total student weight) (LaRoche et al., 2016). At the school level, where class and school variables were combined, no weighting was applied. Variables at the student level were centralized around the group mean, whereas variables at the school level were centralized around the overall mean (Paccagnella, 2006). Centralization is accomplished by subtracting the mean value from each data set value (Garson, 2019). The problem of multicollinearity is reduced by centralization (Enders & Tofighi, 2007; Garson, 2019; Hox et al., 2018).

2.2. Data Collection

Five plausible values calculated from the students' science and mathematics achievement scores in TIMSS were used as dependent variables in the study. Plausible values indicate the range of abilities that the student is thought to have, based on the student's answers to the items in the test (Wu, 2005). Laukaityte and Wiberg (2017) stated that the coefficient estimates and standard error are more accurate when there is more than one plausible value. Furthermore, the manner plausible values are incorporated into the study is very crucial in the validity of the results, as mentioned by Raudenbush and Bryk (2002). The independent variables used in the study were obtained from student, teacher, and school questionnaires. Datasets were downloaded from the TIMSS and PIRLS web page (https://timssandpirls.bc.edu/timss2015/international-database/). The dependent and independent variables (student survey, teacher survey, and school survey) were combined with the IEA IDB analysis program and then edited and made ready for the analysis.

2.2.1. *Achievement tests*

TIMSS achievement tests assess a student's knowledge and abilities in a subject area. The subjects in the TIMSS achievement tests were organized according to the content dimension, which selected the subject to be examined, and the cognitive dimension, which evaluated the thinking processes. Four topic areas were tested on the TIMSS 2015 science achievement test: biology, chemistry, physics, and earth science. On the content dimension of the science achievement test, biology comprises 35%, chemistry 20%, physics 25%, and earth science 25% (Jones et al., 2013). Four topic areas were assessed on the mathematics assessment: number, algebra, geometry, data analysis and probability. The mathematics achievement test's content dimension consists of 30% number, 30% algebra, 20% geometry, 20% data analysis and probability (Gronmo et al., 2013). The cognitive dimension consists of three domains that describe the thinking process that students are required to employ when responding to the TIMSS 2015 science questions. 35% of the questions on the science achievement tests were based on cognitive dimensions of knowing, 35% on cognitive dimensions of applying, and 30% on cognitive dimensions of reasoning (Jones et al., 2013). 35% of the questions on the mathematics achievement tests were based on the cognitive dimension of knowing, 40% on the cognitive dimension of applying, and 25% on the cognitive dimension of reasoning (Gronmo et al., 2013).

2.2.2. *Questionnaires*

While the majority of science and mathematics achievement learning occurs at school and at home, extracurricular activities also influence students achievement (Hooper et al., 2013). The TIMSS 2015 questionnaires collect information about national and societal issues, family, school, and classroom environments, as well as student characteristics and learning attitudes, so that these things can be taken into account when evaluating students. The majority of TIMSS 2015 student, teacher, and school context questionnaire items were designed to be combined into scales that measure a single latent construct. Using item response theory scaling methods, scales for reporting were created (especially the Rasch partial credit model). According to international success criteria, TIMSS classified students into levels corresponding to high, medium, and low values in the structure. To simplify the interpretation of the levels, cut-off points have been established. The data obtained from TIMSS student responses were reconstructed to have a scaled mean score of 10 and a standard deviation of 2 (Martin et al., 2016b). Table 1 and Table 2 contain the definitions and levels as well as variables with and without latent features used in the study and Cronbach alpha reliability coefficients of the latent variables.

2.3. Data Analysis

The TIMSS data set has a hierarchical structure. For this reason, the multilevel modelling (MLM) method was used in the analysis. Since a whole classroom from each school was taken into the sample for the Türkiye, two-level MLM was carried out in the study as first-level students and second-level schools. Analyses were performed with the HLM8 package program. Multilevel modeling is used to test the relationship between variables measured at different levels of multilevel data (Hox, 2010). Multilevel modeling has the advantage of not requiring the independence of errors assumptions (Tabachnick & Fidell, 2013). MLM, like all statistical models, is based on assumptions (Snijders & Boskers, 2012). In this study, the assumptions of the normal distribution of the first and second level errors and the lack of multicollinearity between the independent variables were satisfied, whereas the assumption of the homogeneity of the first level variances was not. The majority of MLM specialists advise using the so-called "sandwich estimator" rather than the traditional "maximum likelihood estimator" to ensure that clustering or grouping does not influence the standard errors (Raudenbush & Bryk, 2002; White, 1980). The HLM package program produces robust standard error tables for such cases (Raudenbush et al., 2011). Since the situation of varying variance is generally encountered in educational research, the data of robust estimation methods tables were evaluated in the study.

Table 1
Information on Student Variables

Dependent/Independent variables	*Description*	*Coding*	*Cronbach Alpha*
PV1-PV5	Plausible values		
Gender	This variable consists of two categories.	Girl=0 Boy=1	
Home educational resources	It is a continuous latent variable created according to students' answers to three statements such as "number of books at home", "parents' education level", "having a room of their own and/or internet connection".		0.62
Like learning science Like learning mathematics	It is a continuous latent variable created according to the degree to which students agree with nine statements such as "learning science/mathematics is enjoyable", "science/mathematics lesson is boring*", and "I like science/mathematics lesson".		0.88 0.92
Value learning science Value learning mathematics	It is a continuous latent variable created according to the degree to which students agree with nine statements such as "I think learning science/mathematics will help me in my daily life.", "I need to be good at science/mathematics to be able to do the job I want," and "learning science/mathematics is important to progress in the world."		0.90 0.87
Confidence in learning science	It is a continuous latent variable created according to the degree to which students agree with eight statements such as "science is not one of the fields I am successful in*," "I learn subjects quickly in science class," and "my teacher says I am good at science."		0.84
Confidence in learning mathematics	It is a continuous latent variable created according to the degree to which students agree with nine statements such as "mathematics is not one of the areas in which I am successful," "I learn subjects quickly in mathematics lessons," and "my teacher says I am good at mathematics."		0.87
Engagement in science Engagement in mathematics	It is a continuous latent variable created according to the degree of agreement of students with ten statements such as "my teacher is easy to understand", "my teacher is good at explaining science or mathematics", and "my teacher tells me how to do better when I make mistakes".		0.91 0.89
Student bullying	It is a categorical latent variable created according to the degree to which students agree with nine statements such as "I was mocked/nicknamed," "other students made me do things I did not want to do," and "shameful things were shared about me on the internet."	1=Never 2=Once a month 3=Once a week	0.81
Clarity of teaching	It is a continuous variable calculated by averaging the engagement scale scores of each school's students.		
School bullying level	It is a categorical variable calculated by averaging the bullying scale scores of each school's students.	Not bullied=0 Bullied=1	
Socioeconomic status of the school	It is a continuous variable calculated by averaging the home educational resources scale scores of students from each school.		

Note. * reverse coded

Table 2
Information on Teacher and School Variables

Independent variables	*Description*	*Coding*	*Cronbach Alpha*
Teaching experience	It is a continuous variable that expresses the years of teaching experience.		
Education level	It is a categorical variable that expresses the highest formal education level of teachers.	1= Associate's degree 2= Bachelor's degree 3= Master, 4= PhD.	
*Major study area-science	It is a categorical variable that expresses whether teachers have a teaching certificate.	1= Science and science education 2= In science but not in science education 3= In science education, but not in science, 4= In all other fields, 5= Secondary school level.	
*Major study area-mathematics		1= Mathematics and mathematics education 2= In mathematics but not in mathematics education 3= In mathematics education, but not in mathematics, 4= In all other fields, 5= Secondary school level.	
Professional development hours	It is a categorical variable that expresses the time spent by teachers on professional development activities in the last two years in areas such as the content of the course, its teaching, and the curriculum, etc.	1 = None, 2 = less than 6 hours, 3= 6-15 hours, 4= 16-35 hours, 5= more than 35 hours.	
Emphasis on academic achievement: teacher	It is a continuous latent variable created according to the degree of agreement of teachers and school principals with thirteen statements such as "teachers' understanding of school curriculum goals", "parent involvement in school activities", and "students' ability to achieve school academic goals", etc.	<= 9.8 moderate importance < 13.4 and > 9.8 high importance >= 13.4 very high importance.	0.89
Emphasis on academic achievement: school principal		<= 9.6 moderate importance < 13.1 and > 9.6 high importance >= 13.1 very high importance.	0.91

Table 2 continued

Independent variables	*Description*	*Coding*	*Cronbach Alpha*
Job satisfaction	It is a continuous latent variable created according to the answers of teachers to the degree of agreement of seven statements such as "I am happy to be a teacher", "I am enthusiastic about my profession", "I am proud of my work", etc.	<= 7 not very satisfied < 10.3 and >7 satisfied >=10.3 very satisfied.	0.88
Problems with school structure and resources	It is a categorical latent variable that was made based on how much teachers agreed with seven statements, such as "Teachers don't have enough space to work," "Teachers don't have enough teaching materials," "Teachers don't have enough technological resources," etc.	1= Almost no problems 2= Minor problems 3= Moderate to severe problems.	0.88
Safe and orderly school	It is a continuous latent variable created according to the answers of teachers to the degree of agreement of eight statements, such as "the school's safety policies and practices are adequate" and "the school has clear rules about how students should act," etc.	< 7.2 partially safe and orderly < 10.6 and > 7.2 safe and orderly >= 10.6 very safe and orderly.	0.88
Inadequacy of science resources	It is a categorical latent variable that was made based on how much school principals agreed with thirteen statements, such as "teachers who specialize in science," "calculators for teaching science," and "scientific equipment and materials for experiments," etc., which show that general school resources and science resources aren't enough to help teach.	1= Not affected 2= Affected 3= Very affected.	0.88
Inadequacy of mathematics resources	It is a categorical latent variable that was made based on how much school principals agreed with thirteen statements, such as "teachers specializing in mathematics", "calculators required for mathematics teaching", "concrete objects or materials that help students understand numbers or operations," etc., which show that general school resources and mathematics resources aren't enough to help teach.	1= Not affected 2= Affected 3= Very affected.	0.88
School discipline problems	It is a categorical latent variable created according to the degree of agreement of school principals with statements related to eleven school problems such as "coming late to school", "cheating", "threatening or verbal abuse (messages, e-mail, etc.)".	1= Almost no problems 2= Minor problems 3= Moderately serious problems.	0.95

Note. * reverse coded variables

The stepwise method of Hox et al. (2018) was followed for analysis in the study. This method includes five steps. In accordance with the study's research questions, the first four steps were implemented. In the first step, a one-way random effects ANOVA model (unconditional model) was used. Using the results of the analysis, the intraclass correlation coefficient (ICC) computed to see if the variance was enough to continue with MLM. The unconditional model without independent variables is expressed with the Equation (1).

$$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij} \quad (1)$$

In this equation γ_{00}, is the regression constant term, or the students' average achievement in science or mathematics. u_{0j} and r_{ij} are school level and student level residuals, respectively. In this step, ICC, the correlation coefficient between the groups is calculated with the Equation (2).

$$ICC = \frac{\hat{\tau}_{00}}{\hat{\tau}_{00} + \hat{\sigma}^2} \quad (2)$$

Where $\hat{\tau}_{00}$, is the school level variance, and $\hat{\sigma}^2$is the student level variance, ICC is the ratio of the school variance to the total variance. In the second step, gender, home educational resources, like learning lesson, confidence in learning lesson, value learning lesson, engagement in lesson, and student bullying variables were added to the first level of the models and analyzed as having a fixed effect. In this step, a random intercept regression model with fixed regression coefficients was used (Snijder & Bosker, 2012). Thus, the student model is expressed by the Equation (3).

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + u_{0j} + r_{ij} \quad (3)$$

Here, X_{pij} is the p number of independent variables at student level. At this step, the effect of each independent variable on the model at the student level is examined. In the third step, the home educational resources variable was added as a control variable at the student level of the null models, and random intercept regression models with multiple variables were created and separately analyzed for teacher preparation and clarity of teaching, school climate, school safety, and school resources factors. The model used in this step is expressed by the Equation (4).

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + u_{0j} + r_{ij} \quad (4)$$

Here, $Z_{qj}$is the q number of independent variables at school level. This model allows one to examine whether the independent variables at the school level explain the between-school variation in the dependent variable. In the fourth step, the random effects of the independent variables in the student models on student achievement were examined separately, and the variables whose effects were found to be significant were determined. Variables with a significant random effect were added to the first level of school models, although their effect on student achievement was not significant. In these models, home educational resources and the socioeconomic status of the school were used as control variables at the student and school level. Finally, all variables examined within the scope of the study were analyzed together with school models. In this step, the random coefficients regression model was used (Raudenbush & Bryk, 2002). Thus, the school model is expressed as Equation (5).

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + u_{pj}X_{pij} + u_{0j} + r_{ij} \quad (5)$$

In the study, after the analysis of the random coefficient models, the non-significant variables in the school models were removed and the final models were formed. Thus, the student and school variables, which have a significant effect on the science and mathematics achievement of the eighth grade students who participated in the TIMSS 2015 assessment, and characteristics of schools in Türkiye were determined.

After the models were analyzed, the R^2 values, interpreted as the explained variance proportion, were calculated. The proportion of variance explained by each model is calculated with the equations R_1^2 and R_2^2, respectively, at the first level (student level) and second level (school level) (Raudenbush & Bryk, 2002).

$$R_1^2 = \frac{\sigma^2_{r_{ij}}(unconditional\ model) - \sigma^2_{r_{ij}}(compared\ model)}{\sigma^2_{r_{ij}}(unconditional\ model)} \quad (6)$$

$$R_2^2 = \frac{\sigma^2_{u_{0j}}\ (unconditional\ model) - \sigma^2_{u_{0j}}\ (compared\ model)}{\sigma^2_{u_{0j}}\ (unconditional\ model)} \quad (7)$$

The interpretation of these individual R^2 values is dependent on the correlation coefficient values between groups (schools). For instance, if the R^2 value at the highest level is 0.20 and the explained variance proportion in the unconditional model is 0.40, then the compared model explains 20% of the total variance (Hox et al., 2018).

3. Results

The results of the unconditional model analysis are presented in Table 3. Table 4 displays the regression coefficients for the analysis results of other models, while Table 5 displays the variance proportions that have been explained by the models. In addition, Figure 1 displays the graph of these variance proportions. Also, Appendix 1 contains descriptive statistics for the dependent and independent variables for science (Table A1) and mathematics (Table A2).

3.1. School Effect on Science and Mathematics Achievement

According to the fixed effect estimates at the Table 3, the average student achievement for mathematics is 492.31 for science and 456.35 for mathematics. According to the random effect estimates, χ^2 values are significant for students' achievement in science (χ^2=3172.85; $p < 0.01$) and mathematics (χ^2=3381.20; $p < 0.01$).

Table 3
Fixed and Random Effects Estimates for Unconditional Models

Fixed effect		*Coefficient*	*se*	*t*	*df*	*p*
Average achievement, γ_{00}	Science	492.31	4.04	121.91	209	0.000**
	Mathematics	456.35	4.62	98.75	212	0.000**
Random effect		*sd*	*Variance*	χ^2	*df*	*p*
School level, u_0	Science	55.71	3103.19	3172.85	209	0.000**
	Mathematics	62.15	3862.17	3381.20	212	0.000**
Student level, r	Science	77.33	5979.45			
	Mathematics	84.43	7127.79			

ICC value was calculated as 0.34 for science and 0.35 for mathematics. Thus, 34% of the variability in students' science achievement and 35% of the variability in mathematics achievement is due to differences in achievement between schools. The results show that there is enough difference between schools for a multilevel analysis to be done.

3.2. Student-based Differences in Science and Mathematics Achievement

According to the fixed effect estimates of the student model in Table 4, it is clear that confidence in learning the lesson has the strongest effect on both science ($\gamma = 13.76$; $p < 0.01$) and mathematics ($\gamma = 21.58$; $p < 0.01$) achievement. Another affective variable, like learning lesson, has a negative and significant effect on students' mathematics achievement ($\gamma = -4.52$; $p < 0.01$), but it has no effect on science achievement. Also value learning lesson has a negative and significant effect on students' science achievement ($\gamma = -2.63$; $p < 0.01$), but its effect on mathematics achievement is

Table 4
HLM Regression Coefficients for Models

Independent variables		*Regression coefficients*							
		Student model	Teacher preparation and clarity of teaching	School climate	School resources	School safety	Control model	School model	Final model
Teacher preparation and clarity of teaching									
Teaching experience	Sci		2.69* (0.45)					0.08 (0.26)	
	Math		3.60* (0.50)					-0.16 (0.34)	
Education level	Sci		8.24 (10.60)					5.64 (6.72)	
	Math		69.54* (10.95)					10.70 (6.54)	
Major study area	Sci		0.66 (4.06)					-2.91 (2.65)	
	Math		-2.69 (3.98)					0.31 (2.50)	
Professional development hours	Sci		4.77 (3.43)					-0.44 (2.24)	
	Math		1.60 (.37)					-2.83 (1.99)	
Clarity of teaching	Sci		18.92* (5.24)					12.74* (2.93)	16.30* (2.92)
	Math		10.64* (4.50)					9.25* (2.78)	9.94* (2.82)
School climate									
Emphasis on academic achievement: teacher	Sci			7.89* (2.29)				-0.39 (1.69)	
	Math			10.60* (2.21)				-0.27 (2.06)	
Emphasis on academic achievement: school principal	Sci			11.20* (1.80)				4.39* (1.35)	4.39* (1.15)
	Math			13.38 (1.98)				3.80* (1.46)	4.35* (1.49)
Job satisfaction	Sci			3.38* (1.61)				1.37 (1.13)	
	Math			0.64 (2.22)				2.09 (1.32)	
School resources									
Problems with school structure and resources	Sci				-19.42* (5.89)			0.20 (3.62)	
	Math				-17.12* (6.41)			4.52 (3.55)	
Inadequacy of resources	Sci				-2.20 (9.06)			8.71 (4.54)	
	Math				-3.70 (11.66)			3.44 (5.79)	
School safety									
Safe and orderly school	Sci					5.67* (2.01)		0.09 (1.48)	
	Math					6.92* (2.27)		0.52 (1.74)	
School discipline problems	Sci					-19.42* (5.59)		-6.38 (3.76)	
	Math					-20.11* (6.63)		-10.03* (3.76)	-8.58* (3.75)
School bullying level	Sci					-31.39* (8.72)		-11.86* (5.20)	-14.59* (5.77)
	Math					-34.61* (9.00)		-13.14* (6.03)	-13.55* (6.27)
Control model									
Home educational resources	Sci	7.81* (0.80)	11.12* (0.92)	11.12* (0.92)	11.12* (0.92)	11.12* (0.92)	11.12* (0.92)	7.72* (0.79)	7.75* (0.78)
	Math	7.68* (0.84)	12.70* (1.07)	12.70* (1.07)	12.70* (1.07)	12.70* (1.07)	12.71* (1.07)	7.69* (0.85)	7.76* (0.86)
Socioeconomic status of the school	Sci						35.90* (2.38)	27.10* (2.42)	29.10* (2.20)
	Math						28.74* (2.99)	35.72* (3.14)	36.59* (2.79)
Student variables									
Gender	Sci	-11.02* (2.39)						-10.05* (2.31)	-10.73* (2.29)
	Math	-4.10 (2.97)						-4.17 (2.94)	
Student bullying	Sci	-10.13* (2.22)						-9.77* (2.27)	-10.28* (2.64)
	Math	-9.42* (2.68)						-9.54* (2.59)	-10.12* (2.22)
Engagement in lesson	Sci	1.71* (0.85)						1.56 (0.85)	
	Math	1.19 (0.96)						0.99 (0.87)	
Like learning lesson	Sci	-0.12 (0.98)						0.19 (0.94)	
	Math	-4.52* (1.00)						-5.17* (0.91)	-4.56* (0.88)
Value learning lesson	Sci	-2.63* (0.74)						-2.81* (0.72)	-1.98* (0.62)
	Math	-0.94 (0.81)							
Confidence in learning lesson	Sci	13.76* (0.69)						14.00* (0.67)	14.32* (0.61)
	Math	21.58* (0.87)						21.55* (0.87)	21.48* (0.86)

not significant. The effect of the engagement in lesson, from the behavioral characteristics of the students, on the students' science achievement ($\gamma = 1.71;\ p < 0.05$) is low, but it is positive and significant. The variable has no effect on students' mathematics achievement. Gender, from the characteristics of students, has a negative and significant effect on students' science achievement ($\gamma = -11.02,\ p < 0.01$). The average mathematics achievement score of female students is nearly 4 points higher than that of male students. Nevertheless, this difference is not significant. Another student variable home educational resources have a positive and significant effect on students' achievement in science ($\gamma = 7.81;\ p < 0.01$) and mathematics ($\gamma = 7.68;\ p < 0.01$). A one-unit increase in home educational resources variable creates a nearly 8 point difference in students' science and mathematics achievement. Students with many educational resources at home are more successful in science and mathematics. As for the student variable, student bullying has a negative significant effect on student achievement in science ($\gamma = -10.13;\ p < 0.01$) and mathematics ($\gamma = -9.42; p < 0.01$). Students who are bullied once a month or once a week are less successful than other students.

Table 5
Explained Variance Proportions for Science and Mathematics Models

Variance source	*Unconditional model*	*Student model*	*Teacher preparation and clarity of teaching*	*School climate*	*School resources*	*School safety*	*Control model*	*School model*	*Final model*
Science									
Level-2	34		21	38	6	23	64	72	71
Level-1	66	21						25	23
Mathematics									
Level-2	35		27	42	4	23	68	72	73
Level-1	65	30						33	31
Variance components									
Science									
Level-1	5979.45	4744.32	5712.29	5712.22	5712.65	5711.93	5712.47	4487.86	4597.76
Level-2	3103.19	3151.01	2442.79	1907.28	2904.03	2395.84	1111.27	871.53	895.71
Gender								113.01*	155.93*
Home educational resources								18.13*	21.65*
Like learning science								27.96*	
Engagement in science								22.79	
Confidence in learning science								10.07*	18.35*
Mathematics									
Level-1	7127.79	4960.78	6778.50	6777.35	6778.47	6777.32	6776.83	4762.80	4920.76
Level-2	3862.17	3941.72	2799.78	2258.27	3703.36	2994.67	1215.66	1083.32	1030.82
Gender								139.20*	
Home educational resources								9.15	
Engagement in mathematics lesson								30.49*	
Confidence in learning mathematics								9.96*	9.68*

Examining the explained variance rates in Table 5 shows that with the student model, 21% of the student level variability (66%) is explained for science, and 30% of the student level variability (65%) is explained for mathematics. The variance ratio differences between the unconditional model and the student model indicate that different student variables also explain the variability in science and mathematics achievement among students.

3.3. Differences in Science and Mathematics Achievement due to Teacher Preparation and Clarity of Teaching

According to the fixed effect estimates of the teacher's preparation and the clarity of the teaching model in Table 4, when home educational researches controlled for, the teaching experience has a positive and significant effect on the achievement of students in both science ($\gamma = 2.69; p < 0.01$) and mathematics ($\gamma = 3.60; p < 0.01$). A one-unit increase in the variable increases science and mathematics achievement of students by approximately 3 and 4 points, respectively. Also the teacher's education level has a significant and positive effect on the mathematics achievement of students ($\gamma = 69.54; p < 0.01$), but its effect on science achievement is not significant. The other teacher preparation variables examined in the model, major study area and professional development hours, were not found to have a significant effect on students' science or mathematics achievement. The clarity of teaching, which reflects the quality of instruction in the classroom, has a significant effect on both science ($\gamma = 18.92; p < 0.01$) and mathematics ($\gamma = 10.64; p < 0.01$) achievement of students. An increase of one unit in the variable results in an increase of approximately 19 points in the science achievement of students and an increase of approximately 11 points in mathematics achievement.

According to the variance proportions explained for teacher preparation and clarity of teaching model in Table 5, the model explains 27% of the school level variance in mathematics and 21% in science.

3.4. Differences in Science and Mathematics Achievement due to School Climate

According to the coefficient estimates of the school climate model in Table 4, when home educational researches controlled for, school emphasis on academic achievement has a positive and significant effect on both in science (teacher: γ=7.89; p<0.01; school principle: γ=11.20; p<0.01) and mathematics (teacher: γ=10.60; p<0.01; school principle: γ=13.38; p<0.01) achievement of students. The variable's contribution to mathematics achievement is higher than its contribution to science achievement. Job satisfaction, another school climate variable, has a positive and significant effect on students' science achievement (γ=3.38; p<0.05), but its effect is not significant for mathematics.

According to the variance proportions explained for school climate model in Table 5, this model accounts for 42% of the variability in mathematics achievement and 38% of the variability in science achievement of students.

3.5. Differences in Science and Mathematics Achievement due to School Resources

According to the coefficient estimates for the school resources model in Table 4, when home educational researches controlled for, problems with school structure and resources has a negative and significant effect on students' achievement in both science ($\gamma = -19.42; p < 0.01$) and mathematics ($\gamma = -17.12; p < 0.01$). According to this finding, the science and mathematics achievement of the students of teachers who reported having problems due to school structure and lack of resources was lower. Inadequacy of science or mathematics resources has no significant effect on students' achievement.

Examining the explained variance proportions in Table 5 reveals that the school resources model is the model that explains school level variance the least. This model explains 6% of the school level science variance and 4% of the mathematics variance.

3.6. Differences in Science and Mathematics Achievement due to School Safety

According to the coefficient estimates for the school safety model in Table 4, when home educational researches is controlled for, it reveals that a safe and orderly school (science: $\gamma = 5.67$; $p < 0.01$; mathematics: $\gamma = 6.92$; $p < 0.01$), school discipline problems (science: $\gamma = -19.42$; $p < 0.01$; mathematics: $\gamma = -20.11$; $p < 0.01$), and school bullying level (science: $\gamma = -31.39$; $p < 0.01$; mathematics: $\gamma = -34.61$; $p < 0.01$) have significant influence on the science and mathematics achievement of students. In this model, the bullying level of a school has the strongest effect on student achievement. The school bullying level and school discipline problems have a negative and significant effect on student achievement. A safe and orderly school has a positive and significant effect on student achievement.

Examining the variance proportions explained in Table 5 for the school safety model reveals that the model explains 23% of the variance in science and mathematics achievement at the school level. After the school climate model for science, this model explains most of the variation in student achievement.

3.7. Differences in Science and Mathematics Achievement due to Socioeconomic Status

According to the coefficient estimates for the control model in Table 4, home educational resources (science: $\gamma = 11.12$; $p < 0.01$; mathematics: $\gamma = 12.71$; $p < 0.01$) and the socioeconomic status of the school (science: $\gamma = 35.90$; $p < 0.01$; mathematics: $\gamma = 28.74$; $p < 0.01$) variables have a positive and significant effect on student achievement. Thus, students who have many educational resources at home and whose schools are wealthy show higher achievement in science and mathematics. An increase in the socioeconomic status of the school results in an increase of approximately 36 points in science achievement and 29 points in mathematics achievement among students.

Examining the variance proportions explained in Table 5 for the control model reveals that, after the school model, this model explains most of the variance in science and mathematics achievement at the school level. In the control model, the variables of home educational resources and socioeconomic status of the school explain 64% of the variance in science achievement and 68% of the variance in mathematics achievement at the school level.

3.8. Student and School related Differences in Science and Mathematics Achievement

According to the school model coefficients in Table 4, the effects of several student and school level variables that were looked at with different models are no longer statistically significant. Examining the results of school model in which socioeconomic status is controlled at the student and school levels, the effect of teaching experience, one of the teacher's qualifications, on the science and mathematics achievement of students is no longer important. Similarly, the influence of teacher's education level on student mathematics achievement is no longer significant. According to this result, teacher qualifications do not have a significant effect on students' science or mathematics achievement. Furthermore, according to the teachers, the school's emphasis on academic achievement no longer has an effect on how well students do in science and mathematics. Also, the effect of another school climate variable, job satisfaction, on students' science achievement is disappeared. Again, problems related to school structure and resources do not have a significant effect on students' science and mathematics achievement in school model. Similarly, the effect of a safe and orderly school on science and mathematics achievement and the effect of school discipline problems on science achievement, which are the variables that express school safety, disappeared. It was seen that only the engagement in the science lesson variable's effect changed among the student variables. Engagement in lesson no longer has a significant effect on science achievement in the school model.

When the variables that didn't have an effect on student achievement were taken out of the school models, the regression coefficients of the final models showed that the socioeconomic status of the school (science: $\gamma = 29.10$; $p < 0.01$; mathematics: $\gamma = 36.59$; $p < 0.01$) and the confidence in learning the lesson (science: $\gamma = 14.32$; $p < 0.01$; mathematics: $\gamma = 21.48$; $p < 0.01$) were the most important factors at the school and student levels respectively. The clarity of teaching ($\gamma = 16.30$; $p < 0.01$), the school's emphasis on academic achievement ($\gamma = 4.39$; $p < 0.01$), and the school bullying level ($\gamma = -14.59$; $p < 0.05$) are other variables that have an effect on students' science achievement at the school level. The clarity of teaching ($\gamma = 9.94$; $p < 0.01$), the emphasis on academic achievement ($\gamma = 4.35$; $p < 0.05$), school discipline problems ($\gamma = -8.57$; $p < 0.01$), and the school bullying level ($\gamma = -13.55$; $p < 0.05$) are other variables that have a significant effect on students' mathematics achievement at school level. Other significant student level variables that have a significant effect on students' science achievement are gender ($\gamma = -10.73$; $p < 0.01$), home educational resources ($\gamma = 7.75$; $p < 0.01$), value learning science ($\gamma = -1.98$; $p < 0.01$), and student bullying ($\gamma = -10.12$; $p < 0.05$). Other student-level variables that have a significant effect on students' mathematics achievement are home educational resources ($\gamma = 7.76$; $p < 0.01$), like learning mathematics ($\gamma = -4.56$; $p < 0.01$), and student bullying ($\gamma = -10.12$; $p < 0.01$).

When the variance proportions explained for the school model and the final model in Table 5 are examined, it is seen that the school model explains 72% of the variability in both science and mathematics achievement. In the final model, 71% of the differences at the school level were explained by science achievement and 73% by mathematics achievement. In these models, in contrast to previous models, it was believed that student variables would explain differences between schools, and their random effects were evaluated. Examining the random effects of student level variables in the final models revealed that the effects of gender, home educational resources, and confidence in learning the lesson on students' science achievement varied across schools. Only the influence of students' confidence in learning mathematics on their achievement varied from school to school.

4. Discussion

Since the Coleman report, the main focus of school researches has been whether the school has an effect on student achievement and, if so, how large that effect is. The current study's findings show that school/class variables explain 34% of the total variability in students' science achievement, while student variables account for 64% of it. Like in science achievement, school/class variables account for 35% of the total variation in mathematics achievement, while student variables account for 66%. The study's findings are consistent with Coleman's (1990) result that schools explain a range of 5% to 38% of the variation in student achievement, as well as various other studies (Arifoğlu, 2019; Aydın, 2015; Erberber, 2009; Mohammadpour & Abdul Ghafar, 2014; Mohammadpour et al., 2015) using TIMSS Türkiye data. While the variance proportions explained by the models used for the study range between 6% and 72% for science achievement, they do so for mathematics achievement as well, between 4% and 73%. This shows that the school has an effect on student achievement in addition to the student's home background, attitudes, and behaviors.

The results of the study indicate that female students in science have better results in TIMSS 2015 than male students. However, the effect of gender on students' mathematics achievement was not found to be significant. In contrast to the study's results, Aydın (2015) and Aksu et al. (2017) found that female students do better in mathematics. These studies used data from TIMSS 2011 and PISA 2012. Neuschmidt et al. (2008) examined how much the gender differences of eighth grade students who participated in the TIMSS study between 1995 and 2003 narrowed over time and concluded that there was no major change in mathematics, but the gender effect in science could disappear. This prediction of Neuschmidt et al. (2008) is supported by the report in which 20 years of TIMSS are evaluated. The results of the study are in favor of the eighth grade female students. This can be explained by the fact that female students are less likely to be absent from school and are more certain of their ability to learn the lesson.

Several research support the conclusion that students' science and mathematics achievement is strongly affected by their confidence in their ability to understand the lesson (Aksu et al., 2017; Aydın, 2015; Aypay et al., 2007; Brookover et al., 1979; Kiray et al., 2015; Liou & Liu, 2015; Mohammadpour & Abdul Ghafar, 2014; Mohammadpour, 2013; Mohammadpour et al., 2015; Olmez, 2020). According to the results of the study, the contribution of confidence in learning to students' mathematics achievement is higher than that of science achievement. This shows that the student's environment and the teacher's endearment of the lesson to the students may result in an increase in mathematics achievement. Again, the effect of learning the lesson on mathematics achievement is negative and significant (Sarı et al., 2017; Yavuz et al., 2017), but its effect on science achievement is not significant (Yildirim & Demir, 2014). Türkiye ranks third among the countries participating in the TIMSS 2015 study in terms of like learning science a lot (Martin et al., 2016a; Mullis et al., 2016). Although at a low level, it is arguable whether or not students who say they like mathematics are more unsuccessful. According to Yavuz et al. (2017), this variable's effect size was negligible. Like learning mathematics has no effect on students' achievement in the subject, according to some studies using TIMSS 2011 data (Aydın, 2015; Yildirim & Demir, 2014). According to researches using data from several countries, like learning mathematics increases student achievement (Lamb & Fullarton, 2002; Mohammadpour & Abdul Ghafar, 2014).

Another affective characteristic, value learning the lesson has a negative and significant effect on students' science achievement (Ceylan & Berberoğlu, 2007; Yildirim & Demir, 2014), but its effect on mathematics achievement is not significant (Yildirim & Demir, 2014; Aydın, 2015; Yavuz et al., 2017; Sarı et al., 2017). The reason for this situation may be that students think that science lessons will be more beneficial than mathematics lessons in daily life for their future. According to the results, students who value science are more unsuccessful, albeit at a low level. According to the results of the TIMSS 2015, Turkish students like and value both science and mathematics lessons (Martin et al., 2016a; Mullis et al., 2016). However, the results do not seem consistent with the current study's results. Regarding this situation, Reyes (1984) stated that students develop a positive attitude towards learning in some cases, but this positive attitude does not reflect achievement that both knowledge and positive attitudes are important together and that one is considered inadequate without the other. In the literature, students' intrinsic motivation, it is considered particularly important. Because an internally motivated individual can perform any activity without needing to be externally motivated. Students' intrinsic motivation can be increased by student centered teaching practices by providing them with more opportunities for inquiry-based learning.

The findings demonstrated that differences in socioeconomic status across students and schools accounted for the majority of the school variance together. In line with the results of TIMSS 2015, the socioeconomic level of the school (Arifoğlu, 2019; Gustafsson et al., 2018; Lamb & Fullarton, 2002; Mohammadpour, 2013; Mohammadpour & Abdul Ghafar, 2014) and the home educational resources used as control variables in the study were found to have a positive and significant effect on how well students did in science and mathematics. As a result, students who have more books at home, educated parents, their own rooms, and/or internet connections, as well as the schools where these students attend, are more successful (Akyol et al., 2010; Aypay et al., 2007; Beaton, 1996; Erberber, 2009; Lamb & Fullarton, 2002; Martin et al., 2000; Mohammadpour, 2013; Mohammadpour & Abdul Ghafar, 2014; Mohammadpour et al., 2015; Mullis & Martin, 2017; Önal, 2015; Suna & Özer, 2021; Topçu et al., 2016; Tsai & Yang, 2015). Gustafsson et al. (2018) analyzed data from 50 countries participating in the TIMSS 2011 eighth grade assessment and school characteristics that may reduce the relationship between SES and mathematics achievement. According to the results of the study, Türkiye is among the countries where the socioeconomic status of school has a positive and significant effect on student achievement. A positive coefficient means that the education system is a system that cannot compensate for the SES of the student; a negative coefficient means that the education system is capable of compensating for the student's SES. Some of the countries where socioeconomic status has a negative effect on student achievement are East Asian (Taiwan, Japan, and Singapore) countries, which are the most successful countries in the TIMSS assessment, along with Canada. Caponera and Losito (2016), in their study conducted with TIMSS 2011 data of many countries, stated that socioeconomic status differences are more prominent in Türkiye, Chile, England, Malaysia, and Israel, where inequality is high according to the Gini coefficient. According to the Organisation for Economic Co-operation and Development (OECD) 2014 report, although socioeconomic disadvantage does not directly produce low academic achievement, it is well established that schools and students' socioeconomic backgrounds have a substantial impact on learning outcomes. Because the schools attended by students from wealthy families are of high quality, their families can contribute to enhancing and growing the educational influence of these schools. Schools in a number of countries tend to reproduce models of socioeconomic advantage instead of making sure that learning opportunities and outcomes are shared more fairly.The findings indicate that economic disparity in Türkiye has a significant effect on students' academic performance and that further funding for education is required.

Another important finding of the study is that the school climate variables explains the most variability in student achievement after the control model. When the home educational resources variable was controlled, it was seen that the school's emphasis on academic achievement, according to teachers and according to school principals, has a positive and significant effect on children's achievement in both science and mathematics (Arifoglu, 2019; Dulay & Karadağ, 2017; Lamb & Fullarton, 2002; Mohammadpour, 2013; Mohammadpour et al., 2015; Sarı et al., 2017; Toropova et al., 2020; Tsai & Yang, 2015; Yalcin et al., 2017; Yavuz et al., 2017). In the study, another variable examined with the school climate model was the teacher's job satisfaction. When the school model is used to look at the effects of the school climate variables, the effects of the school's emphasis on academic achievement, according to the teachers, on the students' achievement in science and mathematics have disappeared, as has the effect of job satisfaction on students' achievement in science. However, the coefficient value for school principals' perception of school climate has also decreased significantly. In the study conducted for Singaporean students with TIMSS 2007 data, Mohammadpour (2013), who achieved a similar result, explained this situation with the view that the combination of student characteristics (SES, parental education, and positive attitude towards lessons) is very important in creating a positive school atmosphere. In the present study, school climate was evaluated as a positive school climate and variables expressing a negative school climate were examined with the school safety model. However, both variables are influenced by variables of school environment. A positive school environment is one in which teachers, school principals, and students develop close relationships and in which the students' skills are recognized and encouraged. The school climate is also affected by what students bring to school with them. It is thought that the socioeconomic status of a student at school influences the school climate and, consequently, the student's science or mathematics achievement, either positively or negatively.

Whatever the effects of schools are, they are produced through teachers and curricula (Stringfield & Teddlie, 1988). In the study, when the home educational resources variable was controlled, the effect of the teaching experience of both science and mathematics teachers on achievement was found to be positive and significant, albeit at a very low level (Greenwald et al., 1996; Hanushek et al., 2004; Hedges et al., 1994). Another teacher preparation variable, the effect of education level on students' mathematics achievement is positive and significant (Goldhaber & Brewer, 1997, 2000; Harris & Sass, 2011; Nye et al., 2004) but its effect on science achievement is not significant. However, in the school model, the effect of the teaching experience and education level on student achievement has disappeared (Martin & Mullis, 2013; Mohammadpour & Abdul Ghafar, 2014). In addition, the effects of teachers' major study area (Atar, 2014; Gustafsson & Nilsen, 2016) and professional development hours were not found to have a substantial effect on students' science or mathematics achievement (Burroughs et al., 2019; Önal, 2015). Thus, when socioeconomic status was controlled, it was seen that the teacher qualifications examined in the study did not have a significant effect on students' science and mathematics achievement. Even when controlling for socioeconomic background at the school level, the clarity of teaching has a substantial effect on science and mathematics achievement (Martin & Mullis, 2013; Scherer & Gustafsson, 2015; Nortvedt et al., 2016). This finding demonstrates the significance of the teacher's ability to teach the curriculum to the student. So, teachers who tell their students what is expected of them, try to be easy to understand, present the material in fun ways, and keep their students' motivation up will help their students do well (Martin et al., 2013).

Student bullying and the increase in school bullying have a negative effect on the science and mathematics achievement of students. The effect of student bullying on achievement is much stronger than the engagement in lesson, like learning lesson and value learning lesson. When the educational resources at home and the socioeconomic status of the school variables are controlled the effect of student bullying on the science and mathematics achievement of students remains unchanged, while the effect of the school bullying level is reduced. However, it has the strongest effect on student achievement after the socioeconomic status of the school and confidence in learning the lesson. Both international results and Türkiye results show that the achievement scores of students who are bullied and those who aren't are very different (Martin et al., 2016a; Mullis et al., 2016). In Türkiye, for instance, there is a difference of 74 points in science achievement and 71 points in mathematics achievement between students who are bullied nearly every week and those who have never been bullied. These disparities are higher than the international averages for science and mathematics, which are 62 and 54, respectively. All these results show that bullying is an international problem (Rutkowski & Rutkowski, 2016). Related studies show that, as in this study, student bullying causes an unsafe school environment consisting of less successful students (Fleming & Jacobsen, 2010; Gökkaya & Tekinsav Sütçü, 2020; Lai et al., 2008; Lay & Ng, 2019; Ma, 2002; Martin et al., 2000; Ponzo, 2013; Rutkowski & Rutkowski, 2016; Topçu et al., 2016). The findings indicate that school safety issues are increasing at an alarming rate. To change the unsafe school environment, where teachers and students are most affected, into a positive school environment with warm and friendly relationships, school principals should focus more on the school environment.

Another important result of the study is that school resources explain a small amount of the variation in science and mathematics achievement between students. After controlling for the socioeconomic status of the school, it was seen that problems with school structure and resources, and inadequacy of resources had no effect on student achievement. It is believed that this situation is a result of the socioeconomic status of the school. According to TIMSS 2015 international science and mathematics results, approximately two-thirds (65%) of students attend schools affected by inadequacy of science resources, and similarly, two-thirds (66%) attend schools affected by inadequacy of mathematics resources. In Türkiye, on the other hand, 98% of students attend schools that are affected by the inadequacy of both science and mathematics resources (Martin et al., 2016a; Mullis et al., 2016). Because there are no schools in Türkiye that are not affected by inadequate resources, the difference between schools with adequate science or mathematics resources and other schools could not be identified. Therefore, it seems reasonable to conclude that the variable has no effect on student achievement. Rutter and Maughan (2002), in their study reviewing school effectiveness studies from the 1970s to the 2000s, concluded that the evidence for the influence of school resource level on student achievement is notably weak. The fact that the school expenditures per student of high-performing countries in international comparisons are lower than those of the United States is viewed as one factor that calls into doubt the significance of school inputs in student performance. However, school systems are also about how resources are utilized, not just how much is spent (Woessmann, 2016). According to the results of PISA 2015, the schools where the principals are given the least autonomy are in Greece, Jordan, and Tunisia, along with Türkiye. On average across OECD countries and 32 education systems, socioeconomically advantageous schools have more autonomy than disadvantaged schools. In Türkiye, the national education authorities take responsibility for all duties except those related to school resources and textbooks (OECD, 2016). When the results of the studies mentioned are examined with the results of the present study, it is believed that school principals in Türkiye must make the most of their limited resources and that this circumstance prevents them from fostering a positive school climate.

5. Conclusion

The aim of this study is to find out which student and school factors effect how well Turkish eighth grade students do in science and mathematics in TIMSS 2015. For this reason a total of eight two level models were generated and analyzed for the students' science and mathematics achievement. In these models, the variables of home educational resources and the socioeconomic status of the school were used as control variables, and the effects of students' characteristic, affective, and behavioral characteristics, teacher preparation and clarity of teaching, school resources, school climate, and school safety factors on student achievement were investigated separately and together. According to the findings of the study, students with high confidence, a low degree of being bullied, and a wealth of educational resources at home were more successful in science and mathematics, as well as female students in science. In general, the students at schools with a high socioeconomic status, a high quality of education, an emphasis on academic achievement, and a safe and orderly environment are more successful.

6. Limitations

This study, which is believed to contribute to the existing body of literature, has a number of limitations. The study is limited to the TIMSS 2015 sample. TIMSS generally samples one classroom from each school on a national scale. For this reason, in multilevel modelling, class and school level variables have to be examined at the same level. Teachers with different qualifications are not randomly distributed among students, classes, or schools. Therefore, the ability of TIMSS to represent the teacher sample is low. Because the TIMSS eighth grade data does not contain information on early learning, such as pre-school attendance, this variable couldn't be used as a control variable. The TIMSS 2015 assessment is limited in terms of curricular variables. Since this is not an experiment where units can be changed and given at random, we can't talk about cause and effect.

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Appendix 1. Descriptive statistics for the dependent and independent variables

Table A1

Descriptive Statistics for Dependent and Independent Variables for Science

	Dependent variable	*n*	*Mean*	*SE*	*Minimum value*	*Maximum value*
PV1	First plausible value	5726	492.56	95.14	148.53	799.37
PV2	Second plausible value	5726	493.16	95.60	100.31	780.77
PV3	Third plausible value	5726	493.72	95.38	77.96	743.52
PV4	Fourth plausible value	5726	492.13	96.42	124.91	786.96
PV5	Fifth plausible value	5726	493.12	94.53	87.34	777.45
	Independent variable					
Student level						
Student characteristics	Home educational resources	5726	9.11	1.91	4.23	13.88
	Gender	5726	0.51	0.50	0	1
Affective and behavioral characteristics	Like learning science	5726	10.76	1.95	3.77	13.62
	Engagement in science	5726	10.74	1.83	3.99	12.95
	Confidence in learning science	5726	10.67	2.26	2.82	15.30
	Value learning science	5726	10.42	1.92	4.15	13.16
School Safety	Student bullying	5726	1.38	0.59	1	3
School level		*N*				
Teacher preparation and clarity of teaching	Teaching experience	210	11.52	8.82	1	42
	Education level	210	2.08	0.34	1	4
	Major study area	210	2.12	0.86	1	4
	Professional development hours	210	1.92	1.25	1	5
	Clarity of teaching	210	10.78	0.76	7.60	12.48
School climate	Emphasis on academic achievement: teacher	210	9.08	1.81	3.3	15.02
	Emphasis on academic achievement: school principal	210	8.88	1.94	4.1	16.63
	Job satisfaction	210	9.7	1.92	4.73	12.49
School resources	Problems with school structure and resources	210	2.3	0.73	1	3
	Inadequacy of science resources	210	2.16	0.43	1	3
School Safety	Safe and orderly school	210	9.21	2.06	4.21	14.06
	School discipline problems	210	2.12	0.71	1	3
	School bullying level	210	0.24	0.43	0	1
	Socioeconomic status of the school	210	9.04	1.24	6.19	12.47

Table A2

Descriptive Statistics for Dependent and Independent Variables for Mathematics

	Dependent variable	*n*	*Mean*	*se*	*Minimum value*	*Maximum value*
PV1	First plausible value	5819	458.32	102.71	77	773.03
PV2	Second plausible value	5819	458.99	103.20	30.88	780.64
PV3	Third plausible value	5819	457.86	104.74	54.71	808.36
PV4	Fourth plausible value	5819	455.79	107.11	69.46	794.79
PV5	Fifth plausible value	5819	458.81	105.09	55.51	785.09
	Independent variable					
Student level						
Student characteristics	Home educational resources	5819	9.13	1.9	4.23	13.88
	Gender	5819	0.51	0.5	0	1
Affective and behavioral characteristics	Like learning mathematics	5819	10.25	1.98	4.97	13.98
	Engagement in mathematics	5819	10.55	1.85	3.55	13.6
	Confidence in learning mathematics	5819	9.75	2.3	3.2	15.93
	Value learning mathematics	5819	10.06	2.09	3	13.65
School Safety	Student bullying	5819	1.38	0.59	1	3
School level		*N*				
Teacher preparation and clarity of teaching	Teaching experience	213	9.26	8.02	1	38
	Education level	213	2.04	0.3	1	4
	Major study area	213	1.8	0.93	1	4
	Professional development hours	213	1.85	1.14	1	5
	Clarity of teaching	213	10.6	0.8	7.17	12.44
School climate	Emphasis on academic achievement: teacher	213	9.14	1.94	3.99	15.02
	Emphasis on academic achievement: school principal	213	8.88	1.94	4.1	16.63
	Job satisfaction	213	9.65	1.84	4.73	12.49
School resources	Problems with school structure and resources	213	2.3	0.75	1	3
	Inadequacy of mathematics resources	213	2.14	0.41	1	3
School Safety	Safe and orderly school	213	9.12	2.24	4.21	14.06
	School discipline problems	213	2.12	0.7	1	3
	School bullying level	213	0.23	0.42	0	1
	Socioeconomic status of the school	213	9.06	1.24	6.19	12.47