International Journal of Assessment Tools in Education
2023, Vol. 10, No. 3, 454–481
https://doi.org/10.21449/ijate.1272517
Published at https://ijate.net/ https://dergipark.org.tr/en/pub/ijate ***Research Article***

# The effect of student characteristics and socioeconomic status on mathematics achievement in Türkiye: Insights from TIMSS 2011-2019

**Burçin Coşkun [1,*], Kübra Karakaya Özyer [2]**

[1]Trakya University, Faculty of Education, Department of Educational Sciences, Edirne, Türkiye
[2]Eskişehir Osmangazi University, Faculty of Education, Department of Educational Sciences, Eskişehir, Türkiye

**ARTICLE HISTORY**
*Received: Mar. 28, 2023*
*Revised: July 28, 2023*
*Accepted: Aug. 18, 2023*

**Keywords:**
TIMSS,
Türkiye,
Mathematics Achievement,
8th-grade Students,
Multilevel Modelling.

**Abstract:** This study examines the factors affecting the mathematics achievement of 8th-grade students in Türkiye using data from the TIMSS in 2011, 2015, and 2019. The data were analysed with multilevel (two-level) modelling. The first level was the student, and the second level was the school. At the student level, such affective characteristics as self-confidence in learning mathematics, liking to learn mathematics, and value given to learning mathematics, as well as educational resources, namely at home, gender, and the frequency of speaking the language of the test at home, were taken into consideration. At the school level, the school's socioeconomic status was included in the model. The results showed that self-confidence in learning mathematics is the most important variable affecting students' mathematics achievement in all years. Besides, the school's socioeconomic status has the strongest effect on students' mathematics achievement, which has increased over the years. The study also showed that those students who performed higher achievement in TIMSS 2011, 2015, and 2019 are confident in learning mathematics, have many educational resources at home, frequently speak Turkish at home, and are from affluent schools. On the other hand, for TIMSS 2011 and 2019, female students were more successful than male students. The effect of liking to learn mathematics on achievement was negative and significant only for TIMSS 2015, while the effect of value given to learning mathematics was positive and significant only for TIMSS 2019. However, the effect size values of the variables showed that this effect was not significant in practice.

## 1. INTRODUCTION

The 21st century is a period in which technological advancements are rapidly developing. Due to changing job market conditions, new requirements are also emerging accordingly. The Program and Instruction for 21st Century Skills (P21) framework, which was first introduced in the United States but later accepted worldwide, emphasizes the importance of students having various knowledge, skills, and experiences to succeed in their careers and daily lives (Guo & Woulfin, 2016); within the P21 framework, critical thinking and problem-solving skills are particularly emphasized (Akgündüz et al., 2015). Türkiye has also been affected by these changes in the world, and efforts have been made to outline a new profile for Turkish students (EARGED, 2011) as well. Since mathematics lessons are quite effective in teaching critical

*CONTACT: Burçin Coşkun burcinermegan@gmail.com Trakya University, Faculty of Education, Department of Educational Sciences, Edirne, Türkiye

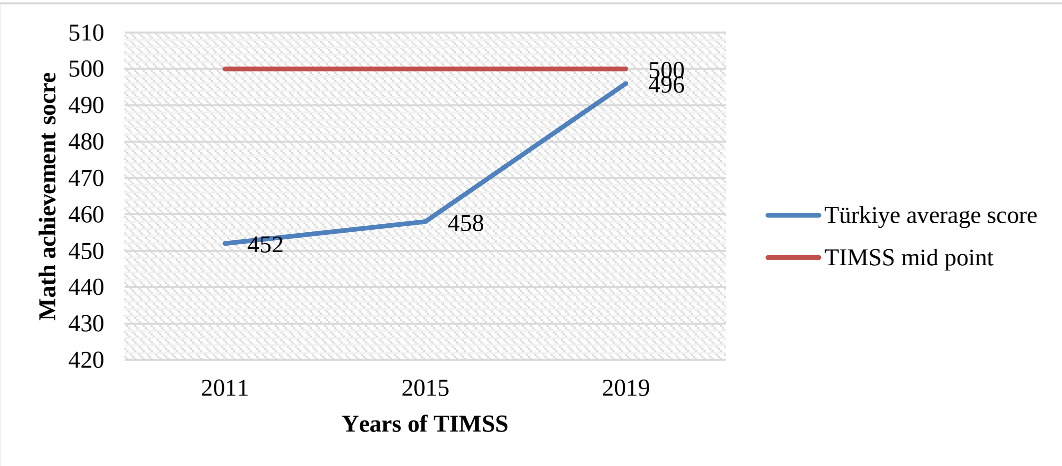
**e-ISSN:** 2148-7456 /© **IJATE** 2023

thinking and problem-solving skills (Mullis & Martin, 2017), Türkiye has taken steps to teach skills such as critical thinking, creative thinking, decision-making, and the use of technology in its mathematics curricula since 2005 (Dönmez & Dede, 2020). It is also important to measure students' mathematical skills and assess them internationally within certain standards. Examples of large-scale international studies in which the mathematical skills of students from many countries can be compared include PISA and the Trends in International Mathematics and Science Study (TIMSS).

TIMSS is the most comprehensive assessment that determines mathematics and science achievement trends of students (National Centre for Education Statistics, n.d.). TIMSS, which was first conducted in 1995, is repeated every four years and draws attention to the changes in the achievements of countries over time. In TIMSS, not only the participants' basic mathematical skills but also their problem-solving and reasoning skills are evaluated (Lee & Chen, 2019). These skills are evaluated in two parts, namely the learning domain and the cognitive domain (Yıldırım et al., 2013). Aside from mathematical skills, TIMSS also collects information about students' affective skills, home lives, and school lives. In particular, with student, school, and teacher questionnaires for 8th grade students, TIMSS endeavours to present all aspects of the educational environment in detail in which the student lives.

Türkiye did not participate in TIMSS in 1995 and 2003, while it participated only with eighth-grade students in 1999 and 2007. In 2011, 2015, and 2019, Türkiye participated with students at both levels (fourth and eighth grades) (Büyüköztürk et al., 2014; Polat et al., 2016; Suna et al., 2020). When looking at the average scores and country rankings for the last three TIMSS studies, there appears to be a quantitative increase (see Figure 1). However, when compared with 500 points, which is the midpoint of the assessment, the mathematics average scores for eighth-grade students in Türkiye remain at the middle level or below the average.

**Figure 1.** *TIMSS 2011, 2015, and 2019 mathematics average scores for eighth-grade students in Türkiye.*




According to its ranking among other participating countries, Türkiye lagged behind 57% of these countries in 2011, 62% in 2015, and 51% in 2019 (Büyüköztürk et al., 2014; Polat et al., 2016; Suna et al., 2020). In addition to examining the mathematics achievement of students in Türkiye from a global perspective, country-based research is also important to focus on the underlying causes of students' success or failure. After each TIMSS report was published, various scientific studies were conducted by taking into account the published data and trying to determine the variables affecting the mathematics achievement of students in Türkiye (e.g., about student characteristics: Abalı-Öztürk & Şahin, 2015; Çalışkan, 2014; Çavdar, 2015; Doğan & Barış, 2010; Sarı et al., 2017; about school characteristics: Akyüz, 2014; Aydın, 2015;

Coşkun & Karadağ, 2023; and about teacher characteristics: Yalcin et al., 2017). It is possible to group these variables in the context of students, teachers, and schools (Thomson et al., 2003). Among the variables studied in the student context are variables that reflect students' affective characteristics (attitudes toward mathematics, motivation levels to learn the lesson, and levels of self-confidence in learning the lesson), socioeconomic status, gender, the frequency of speaking the language of the test at home, and home educational resources.

When the education system in Türkiye is analysed, it is seen that students' acquisition of cognitive skills is much more important than their affective characteristics (Öztekin-Bayır & Tekel, 2021). However, studies showing the relationship between affective characteristics and cognitive skills emphasize the dangers of ignoring affective characteristics in determining students' academic achievement (Ferla et al., 2009; Khine et al., 2015; Leder & Forgasz, 2006; Ölçüoğlu & Çetin, 2016; Pajares & Miller, 1997; Wilkins & Ma, 2003; Wilkins, 2004). When these studies were examined, it was determined that the variables of self-confidence in learning, attitude towards the lesson (liking to learn the lesson), and the value given to the lesson significantly affected academic achievement (Arıkan, 2016; Barış, 2009; Coşkun & Karadağ, 2023; Doğan & Barış, 2010; Kaya, 2008; Louis & Mistele, 2012; Sarı et al., 2017; Yatağan, 2014). When the percentages of affective domain characteristics explaining academic achievement were examined, it was revealed that various studies found different results and that these percentages ranged between 12% and 20% (Chowa et al., 2015). While examining the effect of student characteristics on achievement, it is necessary to control the effect of some variables, especially socioeconomic status, on achievement. Socioeconomic status, gender, and ethnicity (frequency of speaking the language of the test at home) are the variables that explain most of the variance in student achievement (Coleman et al., 1966). In this study, the socioeconomic status of the student and the school were controlled to examine the effect of the variables expressing students' affective characteristics and home backgrounds on TIMSS 2011, 2015, and 2019 mathematics achievement. As a result, all students and schools had the same socioeconomic background (Martin et al., 2013).

## 1.1. Affective Domain

### 1.1.1. *Students' confidence in learning mathematics*

The first of the affective characteristics examined in TIMSS is self-confidence in mathematics, which can be defined as the student's belief in oneself in the mathematics class and seeing oneself as successful in the processing of this class (Demir & Kılıç, 2010). A student's self-confidence in learning the lesson means that he/she does not give up in any negative situations and feels sufficient motivation to correct that situation (Bandura et al., 2001). Both national (Abazaoğlu et al., 2015; Akyüz, 2014; Coşkun & Karadağ, 2023; Demir & Kılıç, 2010; Ertürk & Erdinç-Akan, 2018; Ölmez, 2020; Yalçın et al., 2017) and international (Arıkan et al., 2016; Chen, 2014; Ker, 2016; Papanastasiou, 2000; Wilson & Narayan, 2016; Yoshino, 2012) studies have revealed that students' feeling of self-efficacy while learning the lesson is related to their acquisition of the target behaviours of the lesson.

### 1.1.2. *Students liking to learn mathematics*

The attitudes and emotional states of students play an important role in the process of learning mathematics. The enjoyment of learning mathematics is directly relevant to their intrinsic motivation (Mullis et al., 2012). Enjoying learning mathematics, liking to do mathematics-related homework, and eagerly anticipating a math class all provide clues about students' intrinsic motivation (Hansford & Hattie, 1982). Some studies suggest that the latent variable of 'liking to learn mathematics' derived from the "Students Like Learning Mathematics Scale" (Mullis et al., 2020, p. 428) in TIMMS assessment is a variable that affects academic achievement (Belbase, 2013; Erşan, 2016; Khine et al., 2015; Liou, 2014; Tavşancıl & Yalçın, 2015; Yıldırım et al., 2013). According to these studies, individuals with high intrinsic motivation also tend to have high levels of mathematical achievement. However, some studies that compared different countries obtained different results; for example, Akyüz (2014) examined the effect of affective characteristics on mathematics achievement by analysing the TIMSS 2011 data from Singapore, Finland, the USA, and Türkiye's 8th-grade students: the study findings revealed that, 'liking to learn mathematics' was a significant variable for achievement in Singapore and the United States, but not in Türkiye. Coşkun and Karadağ (2023) found a negative relationship between students' liking to learn mathematics and students' mathematics achievement. Similarly, Kara (2023), using the TIMSS 2019 data from Türkiye, found that as students' enjoyment of learning mathematics decreased, their mathematics achievement increased as well. Such contradictory results indicate that more research is required to understand the impact of students' liking to learn mathematics. Placing greater emphasis on students' emotional states during the process of learning mathematics and increasing research in this area may therefore help to make the process of learning mathematics more effective.

#### 1.1.3. *Students' value given to learning mathematics*

Another affective characteristic associated with students' mathematics achievement is valuing mathematics learning. Value given to learning mathematics refers to students' belief that mathematics is important and will be useful in their future lives (Wigfield & Eccles, 2000). However, in the literature, valuing the lesson is also referred to as external motivation (Ryan & Deci, 2000). In other words, it is an extrinsic motivation source when a student thinks that the mathematics course is important and believes that it will be useful both in daily life and in work life (Wigfield & Eccles, 2000). Some studies have found that there is no relationship between the value given to learning mathematics and academic achievement (Arıkan et al., 2016; Yavuz et al., 2017), while other studies have shown that students who value mathematics use their cognitive skills more consciously and perform better in mathematics exams (Ker, 2016; Kim et al., 2013; Phan et al., 2010). Therefore, students' levels of value for learning mathematics can be an important variable for their mathematics achievement. Understanding the importance of mathematics class and being motivated in this regard can help students achieve higher academic success.

### 1.2. Gender

Various studies show that the most frequently studied variable when investigating factors affecting academic achievement is gender (Aydın, 2015; Karaca, 2018; Louis & Mistele, 2012). National and international studies have compared the achievements of male and female students and investigated the reasons for the differences (Aksu et al., 2017; Mullis et al., 2016). The effectiveness of the gender factor was also investigated in the studies on TIMSS mathematics achievement, and it was determined that there was a significant difference between male and female students (Aydın, 2015; Louis & Mistele, 2012; Martin et al., 2000). Several studies on gender differences have shown that male students have higher mathematics performance than that of female students (Işlak, 2020; Kılıç & Askin, 2013; Louis & Mistele, 2012; Mau & Lynn, 2010; Martin et al., 2000). Studies conducted in Türkiye also support similar results; for example, Kılıç and Askin (2013), based on TIMSS 2011 data, reported that male students have higher mathematics performance than female students have.

However, there are studies showing that female students outperform male students in TIMSS mathematics achievement (Aydın, 2015), while other studies demonstrate that gender is not an important variable in predicting students' mathematics achievement (Coşkun & Karadağ, 2023; Kaleli-Yılmaz & Hanci, 2015; Karaca, 2018; Lee & Kung, 2018; Mohammadpour & Abdul Ghafar, 2014; Sarouphim & Chartouny, 2017). Therefore, most studies suggest that the gender effect on how well students perform in mathematics depends on the TIMSS study year. As a result, it is seen that gender plays an important role in the process of investigating factors affecting academic achievement. However, further research is needed to arrive at a clear conclusion regarding the effect of gender on mathematics achievement.

### 1.3. Language of Test Spoken at Home

Another important factor that affects students' success is the language spoken at home. In the TIMSS study, similarity between the language of the test and the language used at home had a positive effect on students’ achievement. For this reason, it is often questioned how often students speak the test language at home. Students who do not speak Turkish, the language of the test, at home are generally children of minority or immigrant families, which creates difficulties for students to understand and answer the test. The degree to which the language used at home and the language of the exam are similar is crucial to the learning process. The difference between the language spoken at home and the language on the test for children of minority or immigrant families creates some difficulties in the learning process (Lee, 2020). Since the families of these students are usually economically weak, the budget they allocate to their children may also be limited, which may prevent them from accessing new learning opportunities (Coleman, 1994; Portes & MacLeod, 1996). Some studies have shown a positive relationship between the frequency of speaking the language of the test at home and mathematics achievement (Chen, 2014; Ismail & Awang, 2008; Mohammadpour, 2013; Sevgi, 2009). However, in Sandoval-Hernández and Białowolski's (2016) study comparing five countries, a positive relationship was found between the frequency of speaking the test language at home and mathematics achievement in Taipei and Singapore, while a negative relationship was found in Hong Kong. Furthermore, for South Korea and Japan, there was no effect of the frequency of speaking the test language at home on mathematics achievement. In conclusion, the similarity between the language spoken at home and the language of the test is important for students' success. The fact that children of minority or immigrant families are less familiar with the language of the test can be an obstacle to the learning process. Therefore, education systems should create a favourable environment for students' success by considering language differences.

### 1.4. Socioeconomic Status

In a large-scale study conducted in 1966, Coleman et al. (1966) found that the most important factor affecting students' achievement was their socioeconomic status; the effect of schools on achievement was very small, though. Their study has been the basis for many subsequent studies. In TIMSS, socioeconomic status at the student level is determined by the variables of educational resources at home. The educational resources at home are determined by asking about the number of books in the student's home, whether the student has a computer, a room, and an internet connection, and the educational level of the parents. High scores of the student's answers to these questions indicate that he/she has access to a large number of educational resources at home (Sarı et al., 2017). The effect of this variable on achievement can be analysed at both the student and school levels. Since parents with high socioeconomic status can offer more educational opportunities to their children, students' achievement is expected to be higher (Broer et al., 2019; Mullis et al., 2020; Olatunde, 2010; Şirin, 2005). In another study, Chmielewski (2018) found a positive and significant relationship between socioeconomic status and student achievement in his study comparing 30 countries using data from international studies conducted over 50 years.

It is also possible to come across studies that found that the strongest variable affecting the mathematics achievement of 8th-grade students in TIMSS is the socioeconomic status of the student (Bos & Kuiper, 1999; Erşan, 2016; Kılıç & Askın, 2013; Mohammadpour & Abdul

Ghafar, 2012). Türkiye is a heterogeneous country in terms of socioeconomic status and as in the TIMSS Türkiye sample, there are students with very high and very low socioeconomic status (Büyüköztürk et al., 2014; Polat et al., 2016; Suna et al., 2020).

Focusing on the studies conducted in Türkiye, similar results were found to be valid for students in Türkiye and socioeconomic status was found to be effective in explaining student achievement (Akyüz, 2014; Acar-Güvendir, 2014; Bellibaş, 2016; Erdoğan &Acar-Güvendir, 2019; Gelbal, 2008; Kalaycıoğlu, 2015; Karaağaç, Cingöz & Gür, 2020; Özdemir, 2016; Özkan & Acar-Güvendir, 2014; Suna et al., 2020; Tomul & Savaşçı, 2012; Yetkiner-Özel et al., 2013).

However, in schools where the socioeconomic status of the school is high, students have access to more resources and opportunities. This can increase students' academic achievement and help them prepare for a better future. In addition, many studies using TIMSS data have included the school's socioeconomic status in their research. These studies examined how the socioeconomic status of the school affected students' achievement in subjects such as mathematics and science. As a result, the effect of students' socioeconomic status on their achievement should be taken into consideration, and this factor should also be considered in the development of educational policies. Ersan and Rodrigez (2020), in their study with TIMSS 2015 Türkiye data, found that the effect of socioeconomic status is still strong at the school level when the effect of socioeconomic status within and between schools is separated.

### 1.5. Importance of Research

Although TIMSS results have caused various debates since 1995, they have pioneered educational reforms all over the world. The TIMSS study helped to determine the current educational situation and achievement trends by providing the opportunity to compare the mathematics and science achievement levels of Turkish students with those of students in other countries. However, systematic studies are needed to analyse these data well and transform them into educational policy. Since TIMSS data are obtained at different levels (student, school, and teacher levels), multilevel analysis methods should be preferred to minimize the error in the analysis of such data (Bryk & Raudenbush, 1992). In this study, student characteristics that are thought to affect Turkish students' mathematics achievement in TIMSS 2011, 2015, and 2019 were investigated with two-level modelling by controlling socioeconomic status at the student and school levels. When we look at the studies using Turkish TIMSS data in the literature on TIMSS data, it is generally seen that data from a single time are analysed (Akyüz, 2014; Tavşancıl & Yalçın, 2015). However, comparing the data of a country at different times may be more meaningful in showing the effect of the educational policies enacted by the country. In TIMSS 1999, unlike other assessments, students' views on liking and valuing mathematics were questioned through a single scale (the positive attitude toward mathematics scale). In the TIMSS 2007 assessment, student's attitudes towards the lesson were investigated on the scales of positive attitude towards the lesson, value given to learning the lesson, and confidence in learning the lesson. However, since Türkiye participated in this assessment only with 8th-grade students, there is no information on the index variable of educational resources at home. For this reason, the current study aims to draw attention to the changes in factors affecting the mathematics achievement of 8th-grade students in Türkiye over time by analysing TIMSS 2011, 2015, and 2019 data rather than data from a single time period. In this study, therefore, those factors affecting the mathematics achievement of 8th-grade students in TIMSS 2011, 2015, and 2019 are examined. The decision to compare TIMSS data in three different periods was taken because the scales used in these assessments are similar and the 8th grade is defined as the last grade of secondary school in the Turkish education system. This grade level is very important for high school selection and is related to high school success of students in the following years. In Türkiye, 8th-grade students are required to take the high school transition exam at the end of the year and with the score they get from this exam, they have the opportunity to be placed in various high schools. The high school entrance exam is the first large-scale and high-stakes exam for Turkish students and is taken very seriously by students as it directly affects their further education. For these reasons, the success levels of Turkish students in the 8th grade are related to their high school success in the following years (Özdemir & Gelbal, 2016).

In the current study, gender, the frequency of speaking the language of the test at home, and the educational resources at home were also studied while determining the affective characteristics that influenced students' mathematics achievement. Since previous studies have shown that most of the variation in student achievement is due to socioeconomic status, race, and gender (Chmielewski, 2018; Coleman et al., 1966; Hilton & Lee, 1988; Mullis et al., 2020), such variables were also included in the research model.

### 1.6. Research Objective

In this study, the effects of affective characteristics, gender, frequency of speaking the language of the test at home, educational resources at home, and the school's socioeconomic status on the eighth-grade students' mathematics achievement in TIMSS 2011, 2015, and 2019 were investigated. In this context, answers to the stated research problems were sought:

1. Does the mathematics achievement of eighth-grade students in TIMSS 2011, 2015, and 2019 vary between schools?
2. Which student variables (self-confidence in learning mathematics, liking to learn mathematics, value given to learning mathematics, gender, language of test spoken at home, and educational resources at home) have an effect on eighth-grade students' mathematics achievement in TIMSS 2011, 2015, and 2019, when students' socioeconomic status is controlled?

## 2. METHOD

### 2.1. Population and Sample

This study includes an analysis of Türkiye's TIMSS 2011 and 2015 and 2019 eighth-grade data. TIMSS uses a two-level random sampling design in which a school sample is first selected, and then all students in at least one classroom from these schools are sampled (LaRoche et al., 2020). Türkiye's TIMSS 2011, 2015, and 2019 eighth-grade population and sample sizes are given in Table 1. In this study, the missing data were removed from the datasets by the listwise elimination technique, since the missing data rates in the datasets did not exceed 5% (Garson, 2019).

**Table 1.** *Türkiye's TIMSS 2011, 2015, and 2019 population and sample sizes.*

| | Population | | Sample | | Sample size after listwise elimination | |
|---|---|---|---|---|---|---|
| Years | School | Student | School | Student | School | Student |
| 2011 | 17.621 | 1.198.697 | 239 | 6928 | 239 | 6850 |
| 2015 | 15.583 | 1.201.185 | 218 | 6079 | 218 | 5966 |
| 2019 | 16.179 | 1.158.547 | 181 | 4077 | 181 | 3930 |

One of the advantages of working with TIMSS data is that it provides weighting data at the student and school levels. Weighting is important to compensate for the negative effects of situations such as an unequal probability of being selected for sampling or not responding to questions (Von Secker & Lissitz, 1999). These weights are the inverse of the student's probability of being selected for the sample (LaRoche et al., 2016). In the study, student variables were weighted using Total Student Weight (TOTWGT), while no weighting was used for the school variables. In the analyses, the student-level variables were centered on the group mean, and the school-level variable was centered on the overall mean.

## 2.2. Data Collection Tools

The data collection tools of the current study consist of TIMSS 2011, 2015, and 2019 eighth-grade mathematics achievement tests and student questionnaires. TIMSS uses item response theory to describe student achievement on a scale representative of the entire assessment framework and to provide accurate measures of student proficiency distributions and trends (Foy & Yin, 2016). In addition, TIMSS calculates plausible values representing mathematics and science proficiency levels for all students to provide unbiased estimates of the relationship between student achievement and contextual variables (Foy et al., 2020). In the study, five plausible values calculated from the scores of students on mathematics achievement tests were used as dependent variables.

### 2.2.1. *Mathematics achievement test*

This section should indicate the study's design, the sampling, the data collection tools, and the data analysis. Clarification is essential in this part. This section should indicate the study's design, the sampling, the data collection tools, and the data analysis. Clarification is essential in this part.

The TIMSS mathematics tests are made based on comprehensive assessment frameworks that were made with the cooperation of participating countries. Each of the eighth-grade mathematics assessments is organized around two dimensions, namely the content dimension, which indicates the subject or content areas to be evaluated, and the cognitive dimension, which expresses the thinking processes that students can use while engaging with the content (Mullis et al., 2012). The TIMSS 2011, 2015, and 2019 eighth-grade mathematics tests are divided into four content areas: numbers (30%), algebra (30%), geometry (20%), and data and probability (20%). From the three cognitive domains (knowing, applying, and reasoning), TIMSS 2011 placed less emphasis on knowing and more on reasoning (Mullis et al., 2012). In TIMSS 2015, more emphasis was placed on knowing and applying it to the questions and less on reasoning (Gronmo et al., 2013). Most of the TIMSS 2019 mathematics items measure students' practice and reasoning skills (Mullis et al., 2020).

### 2.2.2. *Student questionnaire*

In TIMSS, the questionnaires are administered to students, teachers, and school administrators to learn more about their home, school, and classroom environments. The Student Questionnaire, administered to eighth-grade students, asks students about their home environment, availability of educational resources, and educational experiences related to learning mathematics and science at home and school and includes various scales about attitudes toward learning mathematics and science (Mullis & Fishbein, 2020). In this study, latent or observed variables from questionnaires of students were used as independent variables. Information on the independent variables is provided in the section that follows. Descriptive statistics for these variables are presented in Appendix.

The gender variable consists of two categories (Girl = 1 and Boy = 2); in this study, the gender variable is recoded as Girl = 0, and Male = 1.

The language of test spoken at home expresses how often students use the language of the TIMSS at home (1 = always, 2 = almost always, 3 = sometimes, and 4 = never). In this study, variable levels are reverse-coded.

The "educational resources at home" is a continuous variable created based on the level of agreement of the students with three statements, namely the number of books at home; the education level of the parents; and whether they have a room and/or internet connection of their own. The Cronbach Alpha reliability coefficient of the scale was calculated as 0.63 for TIMSS 2011, 0.62 for TIMSS 2015, and 0.64 for TIMSS 2019.

The 'liking to learn mathematics' is a continuous variable created according to the level of students' agreement with such statements as: I enjoy learning mathematics; I wish I did not have to study mathematics, and mathematics lessons are boring, etc. While the scale consists of five items for TIMSS 2011, it consists of nine items for TIMSS 2015 and 2019.

The 'value given to learning mathematics' is a continuous variable created based on the student's level of agreement with such statements as: I believe that learning mathematics will benefit me in my daily life; I need to be good at mathematics to attend the university of my choice; and to get the job I want, I need to be good at mathematics, etc. While the scale consists of six items for TIMSS 2011, it consists of eight items for TIMSS 2015 and TIMSS 2019. The Cronbach Alpha reliability coefficient of the scale was calculated as 0.75 for TIMSS 2011, 0.87 for TIMSS 2015, and 0.88 for TIMSS 2019.

The 'self-confidence in learning mathematics' is a continuous variable created based on the level of agreement of students with nine statements, such as: I am good at mathematics; I learn mathematics quickly; and my teacher says I am good at mathematics, etc. The Cronbach Alpha reliability coefficient of the scale was calculated as 0.87 for TIMSS 2011 and 2015 and 0.89 for TIMSS 2019.

The 'school's socioeconomic status' is a continuous variable that is calculated by taking the average of the *Home Educational Resources Scale* student scores for the entire school.

### 2.3. Data Analysis

The TIMSS data is organized hierarchically. According to TIMSS data, students are clustered in classes, classes are clustered in schools, and schools are clustered in nations. Hierarchical data cannot be analysed at a single level because clustering implies that individuals in one group will be increasingly similar to persons in other groups. Treating individuals as if they are separate from their social group leads to bias in analyses (Heck & Thomas, 2015). A key assumption of the linear regression model, the independence of the residuals, is relaxed by the multilevel modelling, which is an extension of that model (Snijders & Bosker, 2012). In the study, the analyses were carried out with the HLM 8 package software using the multilevel modelling method.

When the multilevel modelling assumptions were examined with the model created, it was concluded that the first-level and second-level errors were normally distributed, and there was no multicollinearity between the first-level variables. However, it was observed that the homogeneity of variance assumption at the first level analysed with the H test could not be achieved. In general, even though the violation of the homogeneity assumption does not significantly affect the estimation of the coefficient and standard errors, it is nevertheless advised to adopt the robust sandwich approach developed by White (1980) for parameter estimation in these circumstances (Raudenbush & Bryk, 2002). For this reason, robust estimation values produced by HLM using the sandwich estimation method were taken into account in the study (Raudenbush et al., 2011).

Because all students in a classroom are included in the sample in TIMSS Türkiye, classrooms represent schools. Thus, in the study, two-level modelling was done for a first-level student and a second-level school. In the study, firstly, the effect of school on TIMSS 2011, 2015, and 2019 in Türkiye's eighth-grade mathematics achievement was investigated. For this purpose, random effects of one-way ANOVA models (unconditional models) were created and analysed. Equation (1) is an expression of the unconditional model.

$$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij}. \tag{1}$$

Here, $n_j$ stands for the number of students in the *j*th school when the total number of schools is *N*. $Y_{ij}$ is the mathematics achievement score of the *i*th student in the *j*th school. $u_{0j}$ is the school-level error, and $r_{ij}$ is the student-level error (a random error related to the mathematics achievement score of the *i*th student in the *j*th school). The model divides the total variance into two independent components as shown in Equation (2): the first-level error variance $\hat{\sigma}^2$ and the second-level error variance $\hat{\tau}_{00}$ (Hox et al., 2018).

$$var(Y_{ij}) = \hat{\tau}_{00} + \hat{\sigma}^2 \tag{2}$$

Thus, the ratio of the second level variance to the total variance is calculated by the Intraclass Correlation Coefficient (ICC) Equation (3).

$$ICC = \frac{\hat{\tau}_{00}}{\hat{\tau}_{00}+\hat{\sigma}^2}. \tag{3}$$

In the study, random intercept regression models with more than one variable were created and analysed in order to investigate the effect of student characteristics on TIMSS 2011, 2015, and 2019 mathematics achievement by controlling socioeconomic status at the student and school levels (Snijder & Bosker, 2012). This model, in which only the slope coefficient of the constant term changes randomly between schools and the independent variables take place as fixed effects at the first and second levels, is expressed by Equation (4).

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}W_{qj} + u_{0j} + r_{ij}. \tag{4}$$

Here, $X_{pij}$ represents $p$ independent variables at the student level, and $W_{qj}$ represents $q$ independent variables at the school level (Hox et al., 2018).

After determining whether the variables had an effect on student achievement in the study, the effect sizes of the significant variables were investigated. Depending on the purpose of the study, the effect size may be the difference between the means, correlation, a standardized regression coefficient, odds ratio, explained variance ratio, etc. Since the total variance in multilevel modelling consists of two components, within-group ($\hat{\sigma}^2$) and between-groups ($\hat{\tau}_{00}$), the effect size can be calculated in three different ways in these models (Lou et al., 2021). In this study, effect sizes were calculated for the student level by dividing the estimated regression coefficients of the variables ($\gamma_{p0}$) by the student level standard deviation ($\hat{\sigma}$) of the unconditional model. The effect sizes for the school level were calculated by dividing the estimated regression coefficient of the variable ($\gamma_{0q}$) by the school level standard deviation of the unconditional model ($\sqrt{\hat{\tau}_{00}}$ ). The study used the effect size value ranges put forth by Rosenthal and Rosnow (1984). According to these value ranges, the effect size is considered large if it is higher than 0.5 standard deviation, medium if it is between 0.3 and 0.5 standard deviation, small if it is between 0.1 and 0.3 standard deviation, and practically insignificant if it is less than 0.1 standard deviation.

In addition, the variance rates ($R^2$) explained by the models created in the study were calculated by Equation (5) for student level and Equation (6) for school level. In these calculations, unconditional models were taken as reference (Raudenbush & Bryk, 2002).

$$R_1^2 = \frac{\sigma^2_{r_{ij}(unconditional\ model)} - \sigma^2_{r_{ij}(compared\ model)}}{\sigma^2_{r_{ij}(unconditional\ model)}} \tag{5}$$

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

## 3. RESULTS

### 3.1. School Effect on Mathematics Achievement in TIMSS 2011, 2015, and 2019

The analysis results of the unconditional models created to investigate whether there is a difference between schools in terms of the mathematics achievement of students in TIMSS 2011, 2015, and 2019 are given in Table 2. According to the results, the general mathematics achievement averages of the eighth-grade students increased over the years. Nonetheless, Türkiye performed below the TIMSS mean of 500 points in each of the three assessments.

**Table 2.** *Analysis results for unconditional models.*

| Fixed effect | | Coefficient | se | *t* | *df* | *p* |
|---|---|---|---|---|---|---|
| Average, $\gamma_{00}$ | 2011 | 450.64 | 4.25 | 106.06 | 238 | 0.00 |
| | 2015 | 455.51 | 4.58 | 99.53 | 217 | 0.00 |
| | 2019 | 490.88 | 5.18 | 94.75 | 180 | 0.00 |
| Random effect | | *sd* | Variance | $\chi^2$ | *df* | *p* |
| School level, $u_0$ | 2011 | 62.13 | 3859.77 | 3637.17 | 238 | 0.00 |
| | 2015 | 61.75 | 3812.79 | 3426.93 | 217 | 0.00 |
| | 2019 | 64.79 | 4197.50 | 2407.38 | 180 | 0.00 |
| Student level, r | 2011 | 92.04 | 8471.37 | | | |
| | 2015 | 84.65 | 7164.96 | | | |
| | 2019 | 87.64 | 7679.91 | | | |

The 95% confidence intervals for the general mathematics achievement averages of the assessments were calculated with the equation $\gamma_{00} \pm 1.96(\hat{\tau}_{00})^{1/2}$. According to the results, the TIMSS 2011 mathematics achievement scores of the students are between 328.87 and 573.41, the TIMSS 2015 mathematics achievement scores are between 334.48 and 576.54, and the TIMSS 2019 mathematics achievement scores are between 363.89 and 617.87 points.

According to the random effect estimates in Table 2, the differences in mathematics achievement between schools (TIMSS 2011: $\chi^2 = 3637.17; p < 0.05$, TIMSS 2015: $\chi^2 = 3426.93; p < 0.05$, TIMSS 2019: $\chi^2 = 2407.38\ ; p < 0.05$) are significant for all assessments. When the ICC value was computed using Equation (3), it was determined that the differences in achievement between schools accounted for 31% of the variance in students' mathematics achievement for TIMSS 2011 and 35% for TIMSS 2015 and 2019. According to the results, the school effect on students' TIMSS 2011, 2015, and 2019 mathematics achievement is sufficient to be examined with multilevel modelling (Musca et al., 2011). In addition, 69% of the variability in student achievement for TIMSS 2011 is due to differences between students (explained by student variables), while for TIMSS 2015 and 2019, 65% of this variability is due to differences between students (explained by student variables).

### 3.2. The Effect of Student and School Variables on TIMSS 2011, 2015, and 2019 Mathematics Achievement

According to the results in Table 3, the school's socioeconomic status has the strongest effect (TIMSS 2011: γ=34.98; *p*<0.01, TIMSS 2015: γ=41.51; *p*<0.01, TIMSS 2019: γ=43.92; *p*<0.01) on students' mathematics achievement for all TIMSS assessments. A one-unit increase in the school's socioeconomic status leads to an increase of approximately 35 points for TIMSS 2011, 42 points for 2015, and 44 points for 2019 in students' mathematics achievement. Over the years, the estimated coefficient value of the variable also increases. When the effect size values in Table 3 are examined, it is seen that the school's socioeconomic status has a large effect on students' mathematics achievement (Rosenthal & Rosnow, 1984). A one standard deviation increase in the variable is expected to have an effect of 0.56 standard deviation for TIMSS 2011, 0.67 for TIMSS 2015 and 0.68 standard deviation for TIMSS 2019 on students' mathematics achievement.

**Table 3.** *Random intercept regression models with multiple variables.*

| Fixed effect | | Coefficient | se | *t* | *df* | *p* | Effect size |
|---|---|---|---|---|---|---|---|
| Average, $\gamma_{00}$ | 2011 | 450.34 | 2.94 | 153.34 | 237 | 0.000 | --- |
| | 2015 | 455.26 | 2.98 | 152.55 | 75 | 0.000 | --- |
| | 2019 | 490.31 | 3.29 | 148.83 | 179 | 0.000 | --- |
| Level 2 | | | | | | | |
| School's socioeconomic status, $\gamma_{01}$ | 2011 | 34.98 | 2.70 | 12.94 | 237 | 0.000* | 0.56 |
| | 2015 | 41.51 | 2.63 | 15.80 | 216 | 0.000* | 0.67 |
| | 2019 | 43.92 | 3.06 | 14.36 | 179 | 0.000* | 0.68 |
| Level 1 | | | | | | | |
| Gender, $\gamma_{10}$ | 2011 | -6.81 | 2.43 | -2.80 | 122 | 0.006* | -0.07 |
| | 2015 | -5.38 | 2.91 | -1.85 | 19 | 0.080 | --- |
| | 2019 | -8.20 | 3.12 | -2.63 | 84 | 0.010* | -0.09 |
| Language of test spoken at home, $\gamma_{20}$ | 2011 | 10.35 | 2.69 | 3.85 | 65 | 0.000* | 0.11 |
| | 2015 | 8.66 | 2.46 | 3.52 | 145 | 0.001* | 0.10 |
| | 2019 | 7.67 | 3.05 | 2.51 | 98 | 0.014* | 0.09 |
| Educational resources at home, $\gamma_{30}$ | 2011 | 8.62 | 0.78 | 11.03 | 251 | 0.000* | 0.09 |
| | 2015 | 7.54 | 0.90 | 8.36 | 24 | 0.000* | 0.09 |
| | 2019 | 9.75 | 1.23 | 7.95 | 61 | 0.000* | 0.11 |
| Self-confidence in learning mathematics, $\gamma_{40}$ | 2011 | 21.44 | 0.73 | 29.26 | 1075 | 0.000* | 0.23 |
| | 2015 | 21.77 | 0.86 | 25.40 | 25 | 0.000* | 0.26 |
| | 2019 | 19.64 | 1.02 | 19.21 | 53 | 0.000* | 0.22 |
| Liking to learn mathematics, $\gamma_{50}$ | 2011 | -0.53 | 0.91 | -0.59 | 220 | 0.559 | --- |
| | 2015 | -4.15 | 0.96 | -4.33 | 39 | 0.000* | -0.05 |
| | 2019 | -2.02 | 1.27 | -1.59 | 193 | 0.113 | --- |
| Value given to learning mathematics, $\gamma_{60}$ | 2011 | 0.71 | 0.75 | 0.96 | 95 | 0.342 | --- |
| | 2015 | -0.65 | 0.75 | -0.86 | 140 | 0.391 | --- |
| | 2019 | 1.84 | 0.91 | 2.03 | 63 | 0.047* | 0.02 |
| Random effect | | sd | Variance | $\chi^2$ | *df* | *p* | |
| School level, $u_0$ | 2011 | 41.24 | 1700.72 | 2174.89 | 237 | 0.000 | |
| | 2015 | 35.67 | 1272.42 | 1731.21 | 216 | 0.000 | |
| | 2019 | 37.47 | 1403.80 | 1204.02 | 179 | 0.000 | |
| Student level, r | 2011 | 76.95 | 5921.30 | | | | |
| | 2015 | 70.90 | 5027.15 | | | | |
| | 2019 | 72.75 | 5293.10 | | | | |

According to the coefficient estimations of student-level variables, self-confidence in learning mathematics has the strongest effect (TIMSS 2011: $\gamma$=21.44; $p$<0.01, TIMSS 2015: $\gamma$=21.77; $p$<0.01, TIMSS 2019: $\gamma$=19.64; $p$<0.01) on students' mathematics achievement. A one-unit increase in the self-confidence in learning mathematics leads to an increase of about 22 points on the TIMSS 2011 and 2015 and 20 points on the TIMSS 2019. A one standard deviation increase in self-confidence in learning mathematics is expected to have an effect of 0.23

standard deviation for TIMSS 2011, 0.26 for TIMSS 2015, and 0.22 for TIMSS 2019 on students' mathematics achievement, while these effect sizes are small.

Another affective variable, the effect of liking to learn mathematics on achievement, was found to be negative and significant for TIMSS 2015 ($\gamma$=-4.15; $p$<0.01). A one-unit increase in the variable decreases students' mathematics achievement by approximately four points. For TIMSS 2011 and TIMSS 2019, the effect of liking to learn the lesson on students' mathematics achievement is not significant. A one-standard deviation increase in the liking to learn mathematics is expected to result in a 0.05 standard deviation decrease in student achievement. The effect of value given to learning mathematics on students' achievement was found to be positive and significant ($\gamma$=1.84; $p$<0.05) only for TIMSS 2019. A one-unit increase in value given to learning mathematics leads to an increase of approximately 2 points in students' achievement. It is expected that a one standard deviation increase in the variable will cause an increase of 0.02 standard deviations in the TIMSS 2019 mathematics achievement scores of students. In practice, the effect sizes of both variables were not found to be significant.

The effect of educational resources at home on students' mathematics achievement (TIMSS 2011: $\gamma$=8.62; $p$<0.01, TIMSS 2015: $\gamma$=7.54; $p$<0.01, TIMSS 2019: $\gamma$=9.75; $p$<0.01), which is one of the variables expressing the home background of the students, is positive and significant for all assessments. A one-unit increase in educational resources at home leads to an increase of about 9 points on the TIMSS 2011, 8 points on the TIMSS 2015, and 10 points on the TIMSS 2019. Likewise, a one standard deviation increase in educational resources at home is expected to result in an increase in TIMSS mathematics achievement of 0.09 standard deviations in 2011 and 2015, and 0.11 standard deviations in 2019. It can be said that the effect size of the variable is practically insignificant for TIMSS 2011 and 2015, but small for TIMSS 2019.

The effect of student characteristics and gender on mathematics achievement was found to be negative and significant for TIMSS 2011 ($\gamma$ = -6.81; $p$<0.01) and TIMSS 2019 ($\gamma$ = -8.20; $p$<0.01). Female students scored approximately 7 points higher for TIMSS 2011 and 8.5 points higher for TIMSS 2019 than male students did. The effect of the variable on students' mathematics achievement is not significant for TIMSS 2015. Based on the effect size values for the gender variable, the average mathematics score of female students in TIMSS 2011 is 0.07 standard deviation higher than the average mathematics score of male students in TIMSS 2011 and 0.09 standard deviation higher than the average mathematics score in TIMSS 2019. These effect size values are not significant in practice.

The language of test spoken at home has a positive and significant effect on how well students perform in mathematics on all assessments. A one-unit increase in speaking the language of the test leads to an increase of about 11 points for TIMSS 2011, 9 points for TIMSS 2015, and 8 points for TIMSS 2019. The effect size of the language of the test was calculated as 0.11 for TIMSS 2011, 0.10 for 2015, and 0.09 for 2019. The effect size of the variable for TIMSS 2019 is not significant in practice, and for other years, the effect size on students' mathematics achievement is small.

Using Equation (6), we can say that the model with more than one independent variable and a constant term that changes randomly explains 56% of the variation at the school level for TIMSS 2011 and 67% of the variation for TIMSS 2015 and 2019. Several school variables that are not included in the model are expected to explain the unexplained amount of variance at the school level. When the explained variance rate at the student level with the model is calculated with Equation (5), it can be said that 30% of the variance at the student level is explained for the TIMSS 2011 and 2015 assessments and 31% for the 2019 one. It is expected that different student-level variables that were not included in the study would explain 70% of the student-level variation for TIMSS 2011 and 2015 and 69% for 2019.

## 4. DISCUSSION and CONCLUSION

International education studies provide important clues about the quality of education in different countries. Therefore, in attempt to improve the quality of education, Türkiye tries to improve its students’ skills by making changes in national education policies based upon TIMSS results. In particular, the preparation of high school transition exam questions with skill-based questions aims to incorporate skills similar to those measured in TIMSS into students’ learning.

However, research shows that Türkiye’s TIMSS mathematics results are below about half of the results of other countries (Büyüköztürk et al., 2014; Polat et al., 2016; Suna et al., 2020). To solve this problem, it is important to investigate the underlying causes. In this study, student characteristics affecting the mathematics achievement of 8th grade students in Türkiye are analysed with a specific aim to improve the education system by designing educational policies according to the characteristics of students.

One of the most important characteristics associated with students’ mathematics achievement is affective characteristics (Akyüz, 2014; Topçu et al., 2016) which are defined as students’ self-confidence in learning the lesson, their liking the lesson, and their value given to learning the lesson in TIMSS. In the current study, only self-confidence in learning the lesson was found to be an important variable in students’ mathematics achievement in all years. In other words, 8th grade students who are self-confident in mathematics receive higher scores on mathematics tests. When the effect size values were analysed, it was determined that self-confidence in learning mathematics was more effective than other affective variables. It can be said that this effect is small according to the effect size value ranges taken as references in the study (Rosenthal & Rosnow, 1984). A meta-analysis study conducted by Çiftçi and Yıldız (2019) revealed that student self-confidence has a moderate effect on academic achievement. Since Cohen’s d effect size value ranges were taken as references in this study, they differed from the results of the current study. When other studies in the literature are examined, it is seen that there is a positive relationship between mathematics achievement and self-confidence in learning mathematics (Akyüz, 2014; Arıkan et al., 2016; Aydın, 2015; Chen, 2014; Coşkun & Karadağ, 2023; Demir & Kılıç, 2010; Kadijević, 2008; Ismail, 2009; Ismail & Awang, 2012; Lee & Chen, 2019; Lee & Stankov, 2018; Wang et al., 2023). Ismail (2009), in a study conducted with TIMSS 2003 data, stated that self-confidence in learning mathematics is the strongest variable explaining students’ mathematics achievement. Similarly, Khine et al. (2015) designed a structural equation model explaining the mathematics achievement of students’ affective characteristics with TIMSS 2011 data and revealed that the greatest contribution to mathematics achievement was due to self-confidence. This finding was also found in other large-scale studies other than TIMSS. For example, studies conducted with PISA data also found a positive and significant relationship between students’ mathematics self-confidence and mathematics domain skills (Okatan & Tomul, 2020; Sarıer, 2021; Usta & Demirtaşlı, 2018). As a result, students with high self-confidence experience less anxiety and hesitate less because they are confident in themselves. Thus, they can benefit more from mathematical learning environments. Especially in view of the finding that the variable of students' self-confidence explains mathematics performance at a significant level in all years, a programme can be developed to make students self-confident in mathematics lessons, and whether this programme increases their mathematics performance can be tested with experimental research. For this reason, designing textbooks and lesson plans from easy to difficult can support students’ self-confidence in learning mathematics.

The results of the analysis, based on TIMSS 2015 data, showed that the variable ‘liking to learn mathematics’ has a negatively significant effect on students’ mathematics achievement. However, there is no such relationship for TIMSS 2011 and 2019 data. The results obtained for

TIMSS 2015 reveal that students who like mathematics have lower mathematics achievement. However, the effect size of the variable 'liking to learn mathematics' is not practically significant. Unlike the current study, Kara (2023) and Coşkun (2022) found a negative relationship between liking mathematics and students' mathematics achievement in studies conducted with TIMSS 2019 data. The fact that different student variables were also used in these studies may have caused this effect for TIMSS 2019. The results obtained in our study differ from some other studies in the literature. Previous studies have found a positive relationship between enjoyment of learning mathematics and mathematics achievement (Mohammadpour, 2012; Tavşancıl & Yalçın, 2015). Therefore, it is expected that mathematics achievement of secondary school students will increase with the increase in their level of liking mathematics. When the studies conducted on the TIMSS Türkiye sample were analysed, it was determined that some of them used a single-level correlational analysis. The use of different analysis models may therefore cause differences in the results. In this study, a multilevel analysis method was used, and school level variability was taken under control. In this study, the relationship between value given to learning mathematics learning as the last affective variable and students' mathematics achievement was examined. Valuing learning mathematics can be defined as students' belief that what they learn in mathematics lessons will benefit them in the future (Wigfield & Eccles, 2000). Considering the results of the current study, it was determined that the variable of value given to learning mathematics learning significantly explained students' mathematics achievement only in the 2019 data. Similarly, Yavuz et al. (2017), in their study comparing TIMSS 2007 and 2011 results, showed that there was no significant relationship between the value students placed on mathematics and mathematics achievement. In addition, Arıkan et al. (2016) analysed TIMSS 2007 and 2011 data not only within the scope of Türkiye but also tried to reveal the factors affecting the mathematics achievement of both Turkish and Australian students. According to the results of this study, the variable of value given to learning mathematics was not found to be related to achievement in all years in both countries. In light of the findings, the fact that students do not see mathematics as important does not prevent them from studying and succeeding in the course (Ivanova & Michaelides, 2022). When the effect size values in the current study are analysed, a non-significant effect can be mentioned. In 2018, some changes were made to the mathematics curriculum, and mathematics subjects started to be associated with daily life problems. This change may have been reflected in the TIMSS 2019 results.

Apart from affective characteristics, the gender factor also comes to the fore as a student characteristic. Considering the findings of the current study, a significant relationship was found between gender and mathematics achievement in all years except 2015. In other words, the mathematics achievement of female students is higher than the mathematics achievement of male students. The 2019 High School Entrance Exam (LGS) also yielded similar results. In the LGS mathematics subtest, female students scored higher than male students (Şensoy et al., 2019).

Aydın (2015) obtained similar results in his study with TIMSS 2011 data and showed that the mathematics achievement of female students was higher than that of male students. However, when the author analysed the effect size of the gender variable in his study, he stated that it had a small effect and was not practically significant. On the other hand, the results of the current study contradict some studies in the literature (Bassey et al., 2011; Butt & Dogar, 2014; Mohammadpour, 2013; Ross et al., 2012; Topal, 2021; Yayan & Berberoglu, 2004). Although there is a common belief that men are more successful in mathematics, some meta-analyses show that this belief is not true. Lindberg et al. (2010) summarized 242 studies conducted between 1990 and 2007 and found that gender had no significant effect on mathematics achievement.

The language of the test spoken at home was defined as the frequency of speaking Turkish. Considering that various ethnic groups live in Türkiye and that these ethnic groups preserve their own languages, it can be said that the language of the test spoken at home is important for students in Türkiye. Türkiye is constantly receiving immigrants from war-torn countries such as Afghanistan and Syria and is also a bridge between Europe and Asia. Therefore, there are many children of immigrants in the country (Yılmaz & Şekerci 2016). The results of the current study show that the frequency of students speaking Turkish at home has a significant effect on TIMSS 2011, 2015 and 2019 mathematics achievement. In other words, as the frequency of students speaking Turkish at home increases, their mathematics achievement also increases. Similar results have been obtained in other countries as well (e.g., Chinese Taipei, Hong Kong and Singapore) (Chen, 2014; Sandoval-Hernández & Białowolski, 2016). Looking at the effect sizes for each year, it can be concluded that having the same language spoken at home as the language of the test has a small effect on mathematics achievement. In the TIMSS study, there are skill-based questions in which students are expected to use their ability to understand the problem and produce an answer. Although the questions are designed for mathematical cognitive domain skills, it is also very important to use language skills such as reading comprehension since students cannot produce the correct answer if they do not understand what the question is asking. Therefore, it is necessary to improve the Turkish language skills of students whose mother tongue is not Turkish.

The number of books in the student’s home, having a room of his/her own, the level of computer use at home, and the educational level of his/her parents (mother and father) are defined as the student’s educational resources at home. Studies in the related literature show that educational resources at home are related to students’ mathematics achievement and that students with high access to these resources have higher achievement (Akyüz, 2014; Acar-Güvendir, 2014; Koyuncu, 2021; Mullis et al., 2016; Oral & McGivney, 2013; Özer & Anıl, 2011; Topal, 2021; Topçu et al., 2016; Yayan & Berberoglu, 2004). The findings of the current study also yielded parallel results with those of the literature. The educational resources at home variable examined in the study emerged as an important determinant of mathematics achievement in all years. Although this variable was considered a control variable for socioeconomic status at the school level, the effect of educational resources at the student level still persisted. Therefore, it is important to increase the educational resources at students’ homes. To this end, in Türkiye, between 2012 and 2015, 1,437,800 tablet computers were distributed to students under the FATIH project (http://fatihprojesi.meb.gov.tr/tablet_seti.html). Although this project was a step towards increasing educational resources at home, it was not sufficient on its own and was later shelved. According to the findings of the current study, it can be said that the FATIH project did not make a difference in the TIMSS results, since the effect of educational resources at home on academic achievement emerged in all years. Therefore, more comprehensive and effective ways to increase students’ educational resources at home should be sought. In order to eliminate the inequalities arising from the educational opportunities at home, various practices can be carried out in the classroom or at school. For example, enriching the library corner in the classroom or making the computer lab available to students outside class hours can be among the steps to be taken for equal opportunity.

The school’s socioeconomic status was identified as the factor that most influenced the achievement of eighth grade students in mathematics. Considering the effect sizes of the variables in the multivariate model in all years, it is seen that the school’s socioeconomic status is in the first place. The study reveals that the school’s socioeconomic status has a positive relationship with academic achievement. These findings indicate that schools with students with higher socioeconomic status have higher mathematics achievement. Especially in Türkiye, studies conducted by Arifoğlu (2019) and Gustafsson et al. (2018) confirm that school’s socioeconomic status has a significant effect on students’ mathematics achievement.

Gustafsson et al. (2018) compared TIMSS 2011 data from 50 different countries and found that the mathematics achievement of eighth grade students in Türkiye was related to school socioeconomic status. Similarly, Arifoğlu (2019) examined the factors affecting the mathematics achievement of both fourth and eighth grade students using TIMSS 2015 data from Türkiye. As a result of the study, it was found that the school's socioeconomic status was a significant variable affecting mathematics achievement for both grade levels. These results indicate that the academic achievement of economically disadvantaged students in Türkiye should be lower than expected. This situation is the main indicator of non-compliance with the principle of equal opportunities in education (Coleman et al., 1966). When the effect sizes on the basis of years are analysed, it is seen that the effect size increases as we progress from 2011 to 2019. This means that the achievement gap between economically strong and economically weak students has increased over time. This gap in students' achievement persists into adulthood and increases the economic imbalance in society. Therefore, national and local policies should be developed for disadvantaged students, and learning opportunities in schools be improved.

### 4.1. Conclusion

The Turkish education system has undergone radical changes since 2003 which are based on the impact of comprehensive international studies (TIMSS, PISA, and PIRLS). However, when the results of the present study are analysed, it is observed that the variables affecting student achievement have not changed in the last 13 years, which raises a serious question mark about the effectiveness of the reform policies. The results reveal that factors such as students' self-confidence in mathematics, access to educational resources at home, the language spoken at home being Turkish, and the school's socioeconomic status are determinants of their academic achievement.

In this context, there are concerns about the adequacy of the interventions made for educational reform. The fact that the factors affecting student achievement have remained relatively constant suggests that the reforms have not contributed sufficiently to achievement. In particular, access to educational resources at home plays a significant role in students' mathematics achievement. In addition, the language of the test spoken at home has a significant impact on mathematics achievement and also the school's socioeconomic status is a critical factor determining student achievement.

In conclusion, although it is difficult to give a clear answer to the extent to which the reforms in the Turkish education system have contributed to student achievement, factors such as access to educational resources at home, the language of the test spoken at home, and the school's socioeconomic status seem to play a decisive role in student achievement. Therefore, these factors should be taken into consideration when determining educational policies.

### 4.2. Limitations and Suggestions

There are some limitations in the present study. Firstly, this study was designed within the scope of a relational model. For this reason, the findings should not be interpreted as a cause-and-effect relationship. Next, the current study focused only on the mathematics achievement of 8th grade students in TIMSS data. Therefore, interested researchers can compare the results obtained from this study with the results obtained from 4th grade students by working with their data. In addition, this study has shown that educational resources at home is an important variable; however, which of the variables under the index variable of educational resources at home, such as the number of books in the home, having an individual room, having access to a computer, and parental education levels, is more important is beyond the scope of the current study. For this reason, it is necessary to determine which of these variables is more important in order to develop an education policy in line with the results obtained. Especially with the

COVID-19 pandemic, students' access to education from home has become more critical, and it has become difficult to ensure the principle of equal opportunity in education (Özer & Suna, 2020; Özer et al., 2020). Considering the possibility that the effects of this unexpected situation may be reflected in future TIMSS data, the model used in the current study should be tested again with TIMSS 2023 data.

### Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the authors.

### Authorship Contribution Statement

**Burcin Coşkun**: Investigation, Resources, Methodology, Visualization, Software, Formal Analysis, and Writing-original draft. **Kübra Karakaya Özyer**: Literature Review, Methodology, Supervision, and Writing-original draft.

### Orcid

Burcin Coşkun https://orcid.org/0000-0002-6974-4353
Kübra Karakaya Özyer https://orcid.org/0000-0002-0208-7870

## REFERENCES

Abalı-Öztürk, Y., & Şahin, Ç. (2015). Matematiğe ilişkin akademik başarı-özyeterlilik ve tutum arasındaki ilişkilerin belirlenmesi [Determining the relationships between academic achievement, self-efficacy and attitudes towards maths]. *The Journal of Academic Social Science Studies*, *31*(1), 343-366. http://dx.doi.org/10.9761/JASSS2621

Abazaoğlu, İ., Yıldızhan, Y., & Yatağan, M. (2015). Science and mathematics education in Turkey. *İlköğretim Online*, *14*(2), 557-573. https://doi.org/10.17051/io.2015.77272

Acar-Güvendir, M. (2014). Öğrenci başarılarının belirlenmesi sınavında öğrenci ve okul özelliklerinin Türkçe başarısı ile ilişkisi [Student and school characteristics' relation to Turkish achievement in student achievement determination exam]. *Eğitim ve Bilim, 39*(172), 163-180.

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Çorlu, M.S., Öner, T., & Özdemir, S. (2015). *STEM eğitimi Türkiye raporu* [*STEM education Turkiye report*]. Scala Basım.

Aksu, G., Guzeller, C.O., & Eser, M.T. (2017). Analysis of maths literacy performances of students with Hierarchical Linear Modeling (HLM): The case of PISA 2012 Turkey. *Education & Science*, *42*(191), 247-266. https://doi.org/10.15390/EB.2017.6956

Akyüz, G. (2014). The effects of student and school factors on mathematics achievement in TIMSS 2011. *Education and Science*, *39*(172), 150-162. https://egitimvebilim.ted.org.tr/index.php/EB/article/view/2867

Arıkan, S. (2017). TIMSS 2011 verilerine göre Türkiye'deki ev ödevi ve matematik başarısı arasındaki ilişki [The relationship between homework and mathematics achievement in Turkey according to TIMSS 2011]. *International Journal of Eurasia Social Sciences*, *8*(26), 256-276. https://www.researchgate.net/publication/315726438_TIMSS_2011_VERILERINE_GORE_TURKIYE'DEKI_EV_ODEVI_VE_MATEMATIK_BASARISI_ARASINDAKI_ILISKI

Arıkan, S., van de Vijver, F.J.R., & Yağmur, K. (2016). Factors contributing to mathematics achievement differences of Turkish and Australian students in TIMSS 2007 and 2011. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(8), 2039-2059.

Arifoğlu, A. (2019). *Öğrenci başarısına okul etkisinin araştırılması: TIMSS 2015 Türkiye verisine göre çok düzeyli bir analiz* [*Investigating the effect of school on student* *achievement: A multilevel analysis based on TIMSS 2015 Turkey data*] [Doctoral Disseration]. Hacettepe University.

Aydın, M. (2015). *Öğrenci ve okul kaynaklı faktörlerin TIMMS matematik başarısına etkisi* [*The effect of student and school-related factors on TIMMS mathematics achievement*]. [Unpuplished Doctoral Disseration]. Necmettin Erbakan University.

Bandura, A., Barbaranelli, C., Caprara, G.V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development*, *72*(1), 187-206. https://doi.org/10.1111/1467-8624.00273

Barış, F. (2009). *TIMSS-R ve TIMSS-2007 sınavlarının öğrenci başarısını yordayan değişkenler açısından incelenmesi* [*Investigation of TIMSS-R and TIMSS-2007 exams in terms of variables predicting student achievement*][Master's Thesis]. Hacettepe University.

Bassey, S.W., Joshua, M.T., & Asim, A.E. (2011). Gender differences and mathematics achievement of rural senior. *Mathematics Connection*, 1-8.

Belbase, S. (2013). Images, anxieties, and attitudes toward mathematics. *International Journal of Education in Mathematics, Science and Technology*, *1*(4), 230-237.

Bellibas, M.S. (2016). Who are the most disadvantaged? Factors associated with the achievement of students with low socio-economic backgrounds. *Educational Sciences: Theory and Practice*, *16*(2), 691-710. https://doi.org/10.12738/estp.2016.2.0257

Bos, K., & Kuiper, W. (1999). Modelling TIMSS data in a European comparative perspective: Exploring influencing factors on achievement in mathematics in grade 8. *Educational Research and Evaluation*, *5*(2), 157-179. https://doi.org/10.1076/edre.5.2.157.6946

Broer, M., Bai, Y., & Fonseca, F. (2019). *Socioeconomic inequality and educational outcomes: Evidence from twenty years of TIMSS*. Springer Nature.

Bryk, A.S., & Raudenbush, S.W. (1992). *Hierarchical linear models: Applications and data analysis methods*. Sage Publications.

Butt, I.H., & Dogar, A.H. (2014). Gender disparity in mathematics achievement among the rural and urban high school students in Pakistan. *Pakistan Journal of Social Sciences*, *34*(1), 93-100.

Büyüköztürk, Ş., Çakan, M., Tan, Ş., & Atar, H.Y. (2014). *TIMSS 2011 ulusal matematik ve fen raporu: 8. Sınıflar* [*TIMSS 2011 national math and science report: Grade 8*]. Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü, Milli Eğitim Bakanlığı. https://timss.meb.gov.tr/meb_iys_dosyalar/2022_03/07135958_TIMSS-2011-8-Sinif.pdf

Chen, Q. (2014). Using TIMSS 2007 data to build mathematics achievement model of fourth graders in Hong Kong and Singapore. *International Journal of Science and Mathematics Education*, *12*, 1519-1545. https://doi.org/10.1007/s10763-013-9505-x

Chmielewski, A.K. (2019). The global increase in the socioeconomic achievement gap, 1964 to 2015. *American Sociological Review*, *84*(3), 517-544. https://doi.org/10.1177/0003122419847165

Chowa, G.A., Masa, R.D., Ramos, Y., & Ansong, D. (2015). How do student and school characteristics influence youth academic achievement in Ghana? A hierarchical linear modeling of Ghana YouthSave baseline data. *International Journal of Educational Development*, *45*, 129-140. https://doi.org/10.1016/j.ijedudev.2015.09.009

Cingöz, Z.K., & Gür, B. (2020). The effect of economic, social and cultural status on academic achievement a comparison of PISA 2015 and TEOG 2017 results. *İnsan ve Toplum*, *10*(4), 247-288. https://doi.org/10.12658/M0563

Coleman, J.S. (1994). Family, school, and social capital. In T. Husen & T. N. Postlethwaite (Eds.), *International encyclopedia of education* (2nd ed., pp. 2272–2274). Pergamon Press.

Coleman, J.S., Campbell, E.Q., Hobson, C.J., McPartland, J., Mood, A.M., Weinfeld, F.D., & York, R.L. (1966). *Equality of educational opportunity*. Government Printing Office. https://files.eric.ed.gov/fulltext/ED012275.pdf

Coşkun, B., & Karadağ, E. (2023). The effect of student and school characteristics on TIMSS 2015 science and mathematics achievement: The case of Türkiye. *Journal of Pedagogical Research*, *7*(1), 203-227. https://doi.org/10.33902/JPR.202318875

Çalışkan, M. (2014). Bir derse yönelik duyuşsal giriş özelliklerinin belirlenmesi: Bir ölçme modeli önerisi [Determination of affective entry characteristics for a particular course: A measurement model suggestion]. *Kastamonu Eğitim Dergisi*, *22*(1), 57-68. https://dergipark.org.tr/en/pub/kefdergi/issue/22603/241532

Çavdar, D. (2015). *TIMSS 2011 matematik başarısının öğrenci ve öğretmen özellikleri ile ilişkisi* [*The relationship between student and teacher characteristics and mathematics achievement in TIMSS 2011*] [Master's Thesis]. Gazi University.

Çiftçi, Ş.K., & Yıldız, P. (2019). The effect of self-confidence on mathematics achievement: The meta-analysis of Trends in International Mathematics and Science Study (TIMSS). *International Journal of Instruction*, *12*(2), 683-694. https://doi.org/10.29333/iji.2019.12243a

Demir, I., & Kılıç, S. (2010). Using PISA 2003, examining the factors affecting students' mathematics achievement. *Hacettepe University Journal of Education*, *38*(38), 44-54.

Doğan, N., & Barış, F. (2010). Tutum, değer ve özyeterlik değişkenlerinin TIMSS-1999 ve TIMSS-2007 sınavlarında öğrencilerin matematik başarılarını yordama düzeyleri [The prediction levels of attitude, value and self-efficacy variables on students' mathematics achievement in TIMSS-1999 and TIMSS-2007 exams]. *Eğitimde ve Psikolojide Ölçme ve Değerlendirme Dergisi*, *1*(1), 44-50. https://dergipark.org.tr/tr/pub/epod/issue/5808/77253

Dönmez, S.M.K., & Dede, Y. (2020). Ortaöğretime geçiş sınavları matematik sorularının matematiksel yeterlikler açısından incelenmesi [Analysis of mathematics questions in the exams for transition to secondary education in terms of mathematical proficiency]. *Baskent University Journal of Education*, *7*(2), 363-374. https://buje.baskent.edu.tr/index.php/buje/article/view/327

Eğitimi Araştırma ve Geliştirme Dairesi Başkanlığı. [EARGED]. (2011). *MEB 21. yy öğrenci profili* [*MoNE 21st century student profile*]. https://www.meb.gov.tr/earged/earged/21.%20yy_og_pro.pdf

Erdoğan, E., & Acar-Güvendir, M. (2019). Uluslararası öğrenci değerlendirme programında öğrencilerin sosyoekonomik özellikleri ile okuma becerileri arasındaki ilişki [The relationship between students socioeconomic attributes and their reading skills in Programme For International Student Assessment]. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi*, *20*, 493-523. https://doi.org/10.17494/ogusbd.548530

Ersan, O., & Rodriguez, M.C. (2020). Socioeconomic status and beyond: A multilevel analysis of TIMSS mathematics achievement given student and school context in Turkey. *Large-scale Assessments in Education*, *8*, 1-32. https://doi.org/10.1186/s40536-020-00093-y

Erşan, Ö. (2016). *TIMSS 2011 sekizinci sınıf öğrencilerinin matematik başarılarını etkileyen faktörlerin çok düzeyli yapısal eşitlik modeliyle incelenmesi* [*Investigating the factors affecting the mathematics achievement of TIMSS 2011 eighth grade students with multilevel structural equation modeling*] [Master's Thesis]. Hacettepe University.

Ertürk, Z., & Erdinç-Akan, O. (2018). TIMSS 2015 matematik başarısını etkileyen değişkenlerin yapısal eşitlik modeli ile incelenmesi [The investigation of the variables effecting TIMSS 2015 mathematics achievement with SEM]. *Ulusal Eğitim Akademisi Dergisi*, *2*(2), 14-34. https://doi.org/10.32960/uead.407078

Ferla, J., Valcke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. *Learning and Individual Differences*, *19*(4), 499-505. https://doi.org/10.1016/j.lindif.2009.05.004

Foy, P., & Yin, L. (2016). Scaling the TIMSS 2015 achievement data. In M.O. Martin, I.V.S. Mullis, & M. Hooper (Eds.), *Methods and procedures in TIMSS*. http://timss.bc.edu/publications/timss/2015-methods/chapter-13.html

Foy, P., Fishbein, B., von Davier, M., & Yin, L. (2020). Implementing the TIMSS 2019 scaling methodology. In M.O. Martin, M. von Davier, & I.V.S. Mullis (Eds.), *Methods and Procedures: TIMSS 2019 Technical Report* (pp.12.1-12.146). https://timssandpirls.bc.edu/timss2019/methods/chapter-12.html

Garson, G.D. (2019). *Multilevel modeling: Applications in STATA®, IBM® SPSS®, SAS®, R, & HLM*. SAGE Publications.

Gelbal, S. (2008). The effect of socio-economic status of eighth grade students on their achievement in Turkish. *Egitim ve Bilim*, *33*(150), 1-13.

Gronmo, L.S., Lindquist, M., Arora, A., & Mullis, I.V.S. (2013). TIMSS 2015 mathematics framework (Chapter 1). In I.V.S. Mullis & M.O. Martin (Ed), *TIMSS 2015 Assessment Frameworks* (pp. 11-27). http://timssandpirls.bc.edu/timss2015/frameworks.html

Guo, J., & Woulfin, S. (2016). Twenty-first century creativity: An investigation of how the partnership for 21st century instructional framework reflects the principles of creativity. *Roeper Review*, *38*(3), 153-161.

Gustafsson, J.E., Nilsen, T., & Hansen, K.Y. (2018). School characteristics moderating the relation between student socio-economic status and mathematics achievement in grade 8. Evidence from 50 countries in TIMSS 2011. *Studies in Educational Evaluation*, *57*, 16-30. https://doi.org/10.1016/j.stueduc.2016.09.004

Hansford, B.C., & Hattie, J.A. (1982). The relationship between self and achievement/perfor mance measures. *Review of Educational Research*, *52*(1), 123-142.

Heck, R.H., & Thomas, S.L. (2015*). An introduction to multilevel modeling techniques: MLM and SEM approaches using Mplus.* Routledge.

Hilton, T.L., & Lee, V.E. (1988). Student interest and persistence in science: Changes in the educational pipeline in the last decade. *The Journal of Higher Education*, *59*(5), 510-526. https://doi.org/10.1080/00221546.1988.11780210

Hox, J.J., Moerbeek, M., & Van de Schoot, R. (2018). *Multilevel analysis: Techniques and applications*. Routledge.

Ismail, N.A. (2009). Understanding the gap in mathematics achievement of Malaysian students. *The Journal of Educational Research*, *102*(5), 389-394. https://doi.org/10.3200/JOER.102.5.389-394

Ismail, N.A., & Awang, H. (2008). Differentials in mathematics achievement among eighth-grade students in Malaysia. *International Journal of Science and Mathematics Education*, *6*, 559-571. https://doi.org/10.1007/s10763-007-9109-4

Işlak, O. (2020). *Prediction of mathematics achievement of students attending TIMSS 2015 according to student, family and school variables* [Doktoral dissertation]. Burdur Mehmet Akif Ersoy University.

Ivanova, M., & Michaelides, M.P. (2022). Motivational components in TIMSS 2015 and their effects on engaging teaching practices and mathematics performance. *Studies in Educational Evaluation*, *74*, 101-173. https://doi.org/10.1016/j.stueduc.2022.101173

Kadijević, Đ. (2008). TIMSS 2003: Relating dimensions of mathematics attitude to mathematics achievement. *Zbornik Instituta za Pedagoska İstrazivanja*, *40*(2), 327-346.

Kalaycioglu, D.B. (2015). The influence of socioeconomic status, self-efficacy, and anxiety on Mathematics achievement in England, Greece, Hong Kong, the Netherlands, Turkey, and the USA. *Educational Sciences: Theory and Practice*, *15*(5), 1391-1401. https://doi.org/10.12738/estp.2015.5.2731

Kaleli-Yılmaz, G., & Hanci, A. (2016). Examination of the 8th grade students' TIMSS mathematics success in terms of different variables. *International Journal of Mathematical Education in Science and Technology*, *47*(5), 674-695. https://doi.org/10.1080/0020739X.2015.1102977

Kara, M. (2023). *TIMSS 2019 matematik başarısını açıklayan değişkenlerin çok düzeyli yapısal eşitlik modeli ile incelenmesi* [*Examining the variables explaining TIMSS 2019 Mathematics achievement with multilevel structural equation modeling*] [Master's Degree Thesis]. Hacettepe Univesity.

Karaca, F. (2018). *Sekizinci sınıf öğrencilerinin TIMSS matematik başarılarının bazı değişkenler açısından incelenmesi: Eskişehir ili örneği* [*Investigation of TIMSS mathematics achievement of eighth grade students in terms of some variables: The case of Eskisehir province*] [Master's Thesis]. Eskişehir Osmangazi University.

Kaya, S. (2008). *The effects of student-level and classroom-level factors on elementary students' science achievement in five countries* [Doktoral dissertation]. The Florida State University.

Ker, H.W. (2016). The impacts of student-, teacher-and school-level factors on mathematics achievement: An exploratory comparative investigation of Singaporean students and the USA students. *Educational Psychology*, *36*(2), 254-276. https://doi.org/10.1080/01443410.2015.1026801

Khine, M.S., Al-Mutawah, M., & Afari, E. (2015). Determinants of affective factors in mathematics achievement: Structural equation modeling approach. *Journal of Studies in Education*, *5*(2), 199-211. https://www.researchgate.net/publication/276294926_Determinants_of_Affective_Factors_in_Mathematics_Achievement_Structural_Equation_Modeling_Approach

Kilic, S., & Askin, Ö.E. (2013). Parental influence on students' mathematics achievement: The comparative study of Turkey and best performer countries in TIMSS 2011. *Procedia-Social and Behavioral Sciences*, *106*, 2000-2007.

Kim, S.J., Park, J.H., Park, S.W., & Kim, S.S. (2013). *The effects of school and students' educational contexts in Korea, Singapore, and Finland using TIMSS 2011*. 5th IEA International Research Conference, Singapore. http://www.iea.nl/fileadmin/user_upload/IRC/IRC_2013/Papers/IRC-2013_Kim_etal.pdf

Koyuncu, İ. (2021). TIMSS international benchmarks of eighth graders in mathematics: A correspondence analysis study. *International Electronic Journal of Elementary Education*, *14*(2), 179-194.

LaRoche, S., Joncas, M., & Foy, P. (2016). Sample design in TIMSS 2015. In M.O. Martin, I.V.S. Mullis, & M. Hooper (Eds.), *Methods and procedures: TIMSS 2015 technical report*. http://timss.bc.edu/publications/timss/2015 -methods/chapter-3.html

LaRoche, S., Joncas, M., & Foy, P. (2020). Sample design in TIMSS 2019. In M.O. Martin, M. Von Davier, & I.V.S. Mullis (Eds.), *Methods and procedures: TIMSS 2019 technical report*. https://timssandpirls.bc.edu/timss2019/methods/chapter-3.html

Leder, G.C., & Forgasz, H.J. (2006). Affect and mathematics education: PME perspectives. In *Handbook of research on the psychology of mathematics education* (pp. 403-427). Brill.

Lee, C.Y., & Kung, H.Y. (2018). Math self-concept and mathematics achievement: Examining gender variation and reciprocal relations among junior high school students in Taiwan. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(4), 1239-1252. https://doi.org/10.29333/ejmste/82535

Lee, J. (2020). *Non-cognitive characteristics and academic achievement in Southeast Asian countries based on PISA 2009, 2012, and 2015* (Working Paper No. 233). OECD Education.

Lee, J., & Chen, M. (2019). Cross-country predictive validities of non-cognitive variables for mathematics achievement: Evidence based on TIMSS 2015. *EURASIA Journal of Mathematics, Science and Technology Education*, *15*(8), 2-16. https://doi.org/10.29333/ejmste/106230

Lee, J., & Stankov, L. (2018). Non-cognitive predictors of academic achievement: Evidence from TIMSS and PISA. *Learning and Individual Differences*, *65*, 50-64. https://doi.org/10.1016/j.lindif.2018.05.009

Lindberg, S.M., Hyde, J.S., Petersen, J.L., & Linn, M.C. (2010). New trends in gender and mathematics performance: A meta-analysis. *Psychological Bulletin*, *136*(6), 1123–1135. https://doi.org/10.1037/a0021276

Liou, P.Y. (2014). Investigation of the big-fish-little-pond effect on students' selfconcept of learning mathematics and science in Taiwan: Results from TIMSS 2011. *Asia-Pacific Education Research*, *23*(3), 769-778. https://doi.org/10.1007/s40299-013-0152-3

Louis, R.A., & Mistele, J.M. (2012). The differences in scores and self-efficacy by student gender in mathematics and science. *International Journal of Science and Mathematics Education*, *10*, 1163-1190. https://doi.org/10.1007/s10763-011-9325-9

Luo, W., Li, H., Baek, E., Chen, S., Lam, K.H., & Semma, B. (2021). Reporting practice in multilevel modeling: A revisit after 10 years. *Review of Educational Research, 91*(3), 311-355.

Martin, M.O., Mullis, I.V.S., & Foy, P. (2013). TIMSS 2015 assessment design. In I.V.S. Mullis, & M.O. Martin, (Eds.), *TIMSS 2015 assessment frameworks* (pp. 85–100). TIMSS & PIRLS International Study Center. https://timssandpirls.bc.edu/timss2015/frameworks.html

Martin, M.O., Mullis, I.V.S., Gonzales, E.J., Gregory, K.D., Smith, T.A., Chrostowski, S.J. et al. (2000). *TIMSS 1999: International science report*. International Study Center.

Mau, W.C., & Lynn, R. (2010). Gender differences in homework and test scores in mathematics, reading and science at tenth and twelfth grade. *Journal Psychology, Evolution & Gender*, *2*, 119-125.

Mohammadpour, E. (2012). A multilevel study on trends in Malaysian secondary school students' science achievement and associated school and student predictors. *Science Education*, *96*(6), 1013-1046. https://doi.org/10.1002/sce.21028

Mohammadpour, E. (2013). A three-level multilevel analysis of Singaporean eighth-graders science achievement. *Learning and Individual Differences*, *26*, 212-220. https://doi.org/10.1016/j.lindif.2012.12.005

Mohammadpour, E., & Abdul Ghafar, M.N. (2014). Mathematics achievement as a function of within-and between-school differences. *Scandinavian Journal of Educational Research*, *58*(2), 189-221. https://doi.org/10.1080/00313831.2012.725097

Mullis, I.V.S., & Martin, M.O. (2017). *TIMSS 2019 assessment frameworks*. International Association for the Evaluation of Educational Achievement.

Mullis, I.V.S., & Fishbein, B. (2020). Updating the TIMSS 2019 instruments for describing the contexts for student learning. In M. O. Martin, M. von Davier, & I.V.S. Mullis (Eds.), *Methods and Procedures: TIMSS 2019 Technical Report*. https://timssandpirls.bc.edu/timss2019/methods/chapter-2.html

Mullis, I.V.S., Martin, M.O., Foy, P., Kelly, D.L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. https://timss2019.org/reports/

Mullis, I.V.S., Martin, M., & Loveless, T. (2016). 20 years of TIMSS. *Trends in International Mathematics and Science Study*. http://timssandpirls.bc.edu/timss2015/internationalresults/timss2015/wp-content/uploads/2016/T15-20-years-of-TIMSS.pdf

Mullis, I.V.S., Martin, M.O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. TIMSS & PIRLS International Study Center, Boston College.

Musca, S.C., Kamiejski, R., Nugier, A., Méot, A., Er-Rafiy, A., & Brauer, M. (2011). Data with hierarchical structure: impact of intraclass correlation and sample size on type-I error. *Frontiers in Psychology*, *2*(74), 1-6. https://doi.org/10.3389/fpsyg.2011.00074

National Center for Education Statistics. (n. d.). *Overview*. https://nces.ed.gov/timss/overview.asp

Okatan, Ö., & Tomul, E. (2021). Uluslararası öğrenci başarılarını değerlendirme programı'na (PISA) göre Türkiye'deki öğrencilerin matematik başarıları ile ilişkili değişkenlerin incelenmesi [Investigation of interrelated variables with students success in mathematics according to Programme For International Student Assessment (PISA)]. *Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi*, *57*, 98-125. https://dergipark.org.tr/en/pub/maeuefd/issue/60050/663150

Olatunde, Y.R. (2010). Socio-economic background and mathematics achievement of students in some selected senior secondary schools in Southwestern Nigeria. *Pakistan Journal of Social Sciences*, *7*(1), 23-27.

Oral, I., & McGivney, E. (2013). *Student performance in math and science in Turkey and determinants of success*. Education Reform Initiative.

Ölçüoğlu, R., & Çetin, S. (2016). TIMSS 2011 sekizinci sınıf öğrencilerinin matematik başarısını etkileyen değişkenlerin bölgelere göre incelenmesi [The investigation of the variables that affecting eight grade students' TIMSS 2011 math achievement according to regions]. *Journal of Measurement and Evaluation in Education and Psychology*, *7*(1), 202-220. https://doi.org/10.21031/epod.34424

Ölmez, I.B. (2020). Modeling mathematics achievement using hierarchical linear models. *Elementary Education Online*, *19*(2), 944-957. https://doi.org/10.17051/ilkonline.2020.695837

Özdemir, A., & Gelbal, S. (2016). Predictive power of primary and secondary school success criterion on transition to higher education examination scores. *Journal of Measurement and Evaluation in Education and Psychology*, *7*(2), 309-334.

Özdemir, C. (2016). Equity in the Turkish education system: A multilevel analysis of social background influences on the mathematics performance of 15-year-old students. *European Educational Research Journal*, *15*(2), 193-217. https://doi.org/10.1177/1474904115627159

Özer, Y., & Anıl, D. (2011). Examining the factors affecting students' science and mathematics achievement with structural equation modeling. *Hacettepe University Journal of Education*, *41*, 313-324.

Özer, M., & Suna, H. E. (2020). *Covid-19 salgını ve eğitim* [*Covid-19 pandemic and education*]. In M. Şeker, A. Özer & C. Korkut (Eds.), *Küresel toplumun anatomisi: İnsan ve toplumun geleceği* (p. 171-192). Tuba Publication.

Özer, M., Suna, H.E., Aşkar, P., & Çelik, Z. (2020). The impact COVID-19 school closures on educational inequalities. *Insan ve Toplum*, *10*(4), 217-246. http://doi.org/10.12658/M0611

Özkan, Y.Ö., & Acar-Güvendir, M. (2014). Socioeconomic factors of students' relation to mathematic achievement: comparison of PISA and ÖBBS. *International Online Journal of Educational Sciences*, *6*(3), 776-789. http://dx.doi.org/10.15345/iojes.2014.03.020

Öztekin-Bayır, Ö., & Tekel, E. (2021). Problems of Turkish education system and suggested solutions: What do pre-service teachers think?. *Journal of Pedagogical Research*, *5*(1), 275-292. http://dx.doi.org/10.33902/JPR.2021167894

Pajares, F., & Miller, M.D. (1997). Mathematics self-efficacy and mathematical problem solving: Implications of using different forms of assessment. *The Journal of Experimental Education*, *65*(3), 213-228. https://doi.org/10.1080/00220973.1997.9943455

Papanastasiou, C. (2000). Internal and external factors affecting achievement in mathematics: Some findings from TIMSS. *Studies in Educational Evaluation*, *26*(1), 1-8.

Phan, H., Sentovich, C., Kromrey, J., Dedrick, R., & Ferron, J. (2010). *Correlates of mathematics achievement in developed and developing countries: An analysis of TIMSS 2003 eighth-grade Mathematics scores*. American Educational Research Association, Colorado, USA.

Polat, M., Gönen, E., Parlak, B., Yıldırım, A., & Özgürlük, B. (2016). *TIMSS 2015 ulusal matematik ve fen bilimleri ön raporu 4. ve 8. Sınıflar* [*TIMSS 2015 national math and science preliminary report grades 4 and 8*]. Ölçme, Değerlendirme ve Sınav Hizmetleri Genel Müdürlüğü, Milli Eğitim Bakanlığı. https://timss.meb.gov.tr/meb_iys_dosyalar/2022_03/07135609_TIMSS_2015_Ulusal_Rapor.pdf

Portes, A., & MacLeod, D. (1996). Educational progress of children of immigrants: The roles of class, ethnicity, and school context. *Sociology of Education*, *69*(5), 255-275. https://doi.org/10.2307/2112714

Raudenbush, S.W., Bryk, A.S., Cheong, Y.F., Congdon, R.T., & Du Toit, M. (2011). *HLM 7: Hierarchical linear and nonlinear modeling*. Scientific Software International.

Raudenbush, S.W., & Bryk, A.S. (2002). *Hierarchical linear models: Applications and data analysis methods* (Vol. 1). Sage.

Rosenthal, R., & Rosnow, R. (1984). *Essentials of behavioral research: Methods and data analysis.* McGraw-Hill.

Ross, J.A., Scott, G., & Bruce, C.D. (2012). The gender confidence gap in fractions knowledge: Gender differences in student belief-achievement relationships. *School Science and Mathematics*, *112*(5), 278-288. https://doi.org/10.1111/j.1949-8594.2012.00144.x

Ryan, R.M., & Deci, E.L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*(1), 54–67.

Sandoval-Hernández, A., & Białowolski, P. (2016). Factors and conditions promoting academic resilience: A TIMSS-based analysis of five Asian education systems. *Asia Pacific Education Review*, *17*(3), 511-520.

Sarı, M.H., Arıkan, S., & Yıldızlı, H. (2017). 8. sınıf matematik akademik başarısını yordayan faktörler-TIMSS 2015 [Factors predicting mathematics achievement of 8th graders in TIMSS 2015]. *Eğitimde ve Psikolojide Ölçme ve Değerlendirme Dergisi*, 8(3), 246-265. https://doi.org/10.21031/epod.303689

Sarıer, Y. (2021). PISA uygulamalarında Türkiye'nin performansı ve öğrenci başarısını yordayan değişkenler [Turkey's performance in PISA applications and variables predicting student's success]. *Türkiye Sosyal Araştırmalar Dergisi*, *25*(3), 905-926. https://dergipark.org.tr/en/download/article-file/1167361

Sarouphim, K.M., & Chartouny, M. (2017). Mathematics education in Lebanon: Gender differences in attitudes and achievement. *Educational Studies in Mathematics*, *94*, 55-68. https://doi.org/10.1007/s10649-016-9712-9

Sevgi, S. (2009). *The connection between school and student characteristics with mathematics achievement in Turkey* [Master's thesis]. Middle East Technical University.

Snijders, T.A., & Bosker, R.J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling*. Sage.

Suna, H.E., Şenso, S., Parlak, B., & Özdemir, E. (2020). *TIMSS 2019 Türkiye ön raporu* [*TIMSS 2019 Turkey preliminary report*]. Directorate of Measurement, Evaluation and Testing Services, Ministry of National Education. http://www.meb.gov.tr/meb_iys_dosyalar/2020_12/10173505_No15_TIMSS_2019_Turkiye_On_Raporu_Guncel.pdf

Suna, H.E., Tanberkan, H., Gür, B., Perc, M., & Özer, M. (2020). Socioeconomic status and school type as predictors of academic achievement. *Journal of Economy Culture and Society, 61*, 41-64. https://doi.org/10.26650/JECS2020-0034

Şensoy, S., Suna, H.E., Tanberkan, H., Eroğlu, E., & Altun, Ü. (2019). *2019 first placement results within the scope of the 2019 high school entrance system* (Report no 8). Ministry of National Education. https://mtegm.meb.gov.tr/meb_iys_dosyalar/2019_07/23104940_LGS_2019_yerlestirme_22temmuz.pdf

Şirin, S.R. (2005). Socioeconomic status and academic achievement: A meta-analytic review of research. *Review of Educational Research*, *75*(3), 417-53. https://doi.org/10.3102/00346543075003417

Tavsancil, E., & Yalcin, S. (2015). A determination of Turkish student's achievement using hierarchical linear models in Trends in International Mathematics-Science Study (TIMSS) 2011. *The Anthropologist*, *22*(2), 390-396. https://doi.org/10.1080/09720073.2015.11891891

Thomson, S., Lokan, J., Lamb S., & Ainley, J. (2003). *Lessons from the third international mathematics and science study*. TIMSS Australia Monograph Series. Australian Council for Educational Research. https://research.acer.edu.au/timss_monographs/9/

Tomul, E., & Savasci, H.S. (2012). Socioeconomic determinants of academic achievement. *Educational Assessment, Evaluation and Accountability*, *24*(3), 175-187. https://doi.org/10.1007/s11092-012-9149-3

Topal, H. (2021). Variable selection via the adaptive elastic net: Mathematics success of the students in Singapore and Turkey. *Journal of Applied Microeconometrics*, *1*(1), 41-55. https://doi.org/10.53753/jame.1.1.04

Topçu, M.S., Erbilgin, E., & Arıkan, S. (2016). Factors predicting Turkish and Korean students' science and mathematics achievement in TIMSS 2011. *Eurasia Journal of Mathematics Science and Technology Education, 12*(7), 1711-1737. https://doi.org/10.12973/eurasia.2016.1530a

Usta, H.G., & Demirtaşlı, R.N. (2018). PISA 2012 matematik okuryazarlığı üzerine uluslararası bir karşılaştırma: Türkiye ve Finlandiya [An international comparison according to PISA 2012 mathematical literacy Turkey and Finland]. *Electronic Turkish Studies*, *13*(11), 1389-1420. http://dx.doi.org/10.7827/TurkishStudies.13377

Wang, F., King, R.B., & Leung, S.O. (2023). Why do East Asian students do so well in mathematics? A machine learning study. *International Journal of Science and Mathematics Education*, *21*(3), 691-711. https://doi.org/10.1007/s10763-022-10262-w

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica*, *48*(4), 817–838. https://doi.org/10.2307/1912934

Wigfield, A., & Eccles, J.S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68-81. https://doi.org/10.1006/ceps.1999.1015

Wilkins, J.L., & Ma, X. (2003). Modeling change in student attitude toward and beliefs about mathematics. *The Journal of Educational Research*, *97*(1), 52-63. https://doi.org/10.1080/00220670309596628

Wilson, K., & Narayan, A. (2016). Relationships among individual task self-efficacy, self-regulated learning strategy use and academic performance in a computer-supported collaborative learning environment. *Educational Psychology*, *36*(2), 236-253. https://doi.org/10.1080/01443410.2014.926312

Yalcin, S., Demirtasli, R.N., Dibek, M.I., & Yavuz, H.C. (2017). The effect of teacher and student characteristics on TIMSS 2011 mathematics achievement of fourth-and eighth-grade students in Turkey. *International Journal of Progressive Education*, *13*(3), 79-94. https://eric.ed.gov/?id=EJ1159910

Yatağan, M. (2014). *Fen ve teknoloji dersi öğretim programının öğrenci ve öğretmen özelliklerine göre değerlendirilmesi: TIMSS 2007 ve 2011 verileri ile bir durum analizi* [*Evaluation of science and technology curriculum according to student and teacher characteristics: A case analysis with TIMSS 2007 and 2011 data*] [Unpublished Doctoral Dissertation]. Gazi University.

Yavuz, H.Ç., Demirtaşlı, R.N., Yalçın, S., & Dibek, M.İ. (2017). Türk öğrencilerin TIMSS 2007 ve 2011 matematik başarısında öğrenci ve öğretmen özelliklerinin etkileri [The effects of student and teacher level variables on TIMSS 2007 and 2011 mathematics achievement of Turkish students]. *Eğitim ve Bilim*, *42*(189), 27-47. https://doi.org/10.15390/EB.2017.6885

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

Yetkiner-Özel, Z.E., Özel, S., & Thompson, B. (2013). SES-related mathematics achievement gap in Turkey compared to European Union countries. *Education & Science*, *38*(170), 179-193.

Yıldırım, H.H., Yıldırım, S., Ceylan, E., & Yetişir, M.İ. (2013). *Türkiye perspektifinden TIMSS 2011 sonuçları* [*TIMSS 2011 results from Turkey's perspective*]. Pelin Ofset Tipo Matbaacılık.

Yılmaz, F., & Şekerci, H. (2016). Ana dil sorunsalı: Sınıf öğretmenlerinin deneyimlerine göre ilkokul öğrencilerinin yaşadıkları sorunlar [Native language problematic: Problems faced by primary school students according to the experiences of classroom teachers]. *Eğitimde Nitel Araştırmalar Dergisi*, *4*(1), 47-63. https://dergipark.org.tr/en/pub/enad/issue/32029/354378

Yoshino, A. (2012). The relationship between self-concept and achievement in TIMSS 2007: A comparison between American and Japanese Students. *Int Rev Educ*, *58,* 199-219. https://doi.org/10.007/s11159-012-9283-7

## APPENDIX

### Descriptive Statistics for Dependent and Independent Variables

| | Dependent variables | Year | n | Mean | se | Minimum value | Maximum value |
|---|---|---|---|---|---|---|---|
| PV1 | First plausible value | 2011 | 6850 | 450.79 | 108.58 | 105.73 | 839.23 |
| | | 2015 | 5966 | 457.16 | 102.91 | 77.00 | 773.03 |
| | | 2019 | 3930 | 491.92 | 106.95 | 128.39 | 871.37 |
| PV2 | Second plausible value | 2011 | 6850 | 450.05 | 110.01 | 93.32 | 845.22 |
| | | 2015 | 5966 | 457.92 | 103.38 | 30.88 | 780.64 |
| | | 2019 | 3930 | 493.21 | 107.35 | 115.80 | 866.83 |
| PV3 | Third plausible value | 2011 | 6850 | 449.27 | 111.70 | 59.20 | 875.19 |
| | | 2015 | 5966 | 456.91 | 104.66 | 54.71 | 808.36 |
| | | 2019 | 3930 | 492.63 | 108.59 | 100.62 | 888.37 |
| PV4 | Fourth plausible value | 2011 | 6850 | 449.10 | 110.42 | 44.54 | 917.68 |
| | | 2015 | 5966 | 454.63 | 107.13 | 69.46 | 794.79 |
| | | 2019 | 3930 | 490.41 | 110.01 | 91.89 | 862.05 |
| PV5 | Fifth plausible value | 2011 | 6850 | 450.03 | 110.61 | 95.53 | 840.44 |
| | | 2015 | 5966 | 457.88 | 104.98 | 55.51 | 785.09 |
| | | 2019 | 3930 | 491.69 | 107.86 | 117.26 | 838.33 |
| | Independent variables | | | | | | |
| *Student level* | | | | | | | |
| Student characteristics | Gender | 2011 | 6850 | 0.50 | 0.50 | 0.00 | 1.00 |
| | | 2015 | 5966 | 0.51 | 0.50 | 0.00 | 1.00 |
| | | 2019 | 3930 | 0.50 | 0.50 | 0.00 | 1.00 |
| | Language of the test spoken at home | 2011 | 6850 | 3.67 | 0.73 | 1.00 | 4.00 |
| | | 2015 | 5966 | 3.68 | 0.71 | 1.00 | 4.00 |
| | | 2019 | 3930 | 3.62 | 0.77 | 1.00 | 4.00 |
| | Educational resources at home | 2011 | 6850 | 8.35 | 2.07 | 4.32 | 14.02 |
| | | 2015 | 5966 | 9.11 | 1.90 | 4.23 | 13.88 |
| | | 2019 | 3930 | 9.39 | 1.79 | 4.55 | 13.52 |
| Affective characteristics | Self-confidence in learning mathematics | 2011 | 6850 | 9.72 | 2.20 | 3.18 | 15.82 |
| | | 2015 | 5966 | 9.75 | 2.29 | 3.20 | 15.93 |
| | | 2019 | 3930 | 9.81 | 2.35 | 3.28 | 15.85 |
| | Liking to learn mathematics | 2011 | 6850 | 10.24 | 1.99 | 5.04 | 13.47 |
| | | 2015 | 5966 | 10.26 | 1.98 | 4.97 | 13.98 |
| | | 2019 | 3930 | 10.33 | 1.94 | 5.09 | 13.85 |
| | Value given to learning mathematics | 2011 | 6850 | 9.98 | 1.99 | 3.41 | 13.71 |
| | | 2015 | 5966 | 10.06 | 2.10 | 3.00 | 13.65 |
| | | 2019 | 3930 | 10.07 | 2.08 | 3.04 | 13.48 |
| *School level* | | | *N* | | | | |
| | School's socioeconomic status | 2011 | 239 | 8.30 | 1.35 | 4.84 | 13.09 |
| | | 2015 | 218 | 9.05 | 1.23 | 6.19 | 12.47 |
| | | 2019 | 181 | 9.34 | 1.23 | 6.39 | 12.54 |