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Factors Predicting Turkish Students' Mathematics and Science Achievement in TIMSS 2019

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ABSTRACT

The study aims to investigate how confidence in mathematics/science, amount of books in the home, gender, whether a student likes being in school, and computer software predicted mathematics and science achievements of students in the Trends in International Mathematics and Science Study (TIMSS) 2019. The sample of the study consisted of eighth-grade Turkish students, 1784 students in mathematics, 1776 students in science, and 72 school principals. Multiple linear regression was conducted using the Statistical Package for the Social Sciences (SPSS) and International Database (IDB) Analyzer, which provides a way to combine five plausible values of achievement scores. The study results indicated that the amount of books in the home, whether the student liked being in school, and the students' confidence in mathematics/science significantly predicted mathematics and science achievements. Confidence in mathematics/science contributed the most to predicting achievement among the variables after controlling for the other predictors.

Keywords: multiple linear regression, mathematics achievement, science achievement; TIMSS 2019, IDB Analyzer.

Introduction

Countries give importance to pursuing the effectiveness of education. Large-scale assessments provide opportunities for countries to both follow the outputs of the current education system and compare it with the outcomes of previous systems and other countries (Wagemaker, 2013). Science and mathematics are two critical indicators for governments to monitor the effectiveness of their education system (EACEA, 2022); therefore, large-scale assessments concentrate on assessing these two subjects.

Mathematics and science are two essential subjects that provide students with opportunities to gain 21st-century skills, such as critical thinking, problem-solving, reasoning, creativity, and curiosity (e.g., Bircan & Akman, 2023; Woods-Groves et al., 2021). Furthermore, these two subjects help students to gain financial and scientific literacy. Therefore, high mathematics and science achievement have a crucial role in preparing students to keep up with the needs of the changing world (EACEA,

2022). Even though the importance of mathematics and science achievement is evident, it is seen that Turkish students' mathematics and science achievement is not adequate when compared to other countries. According to the Trends in International Mathematics and Science Study (TIMSS) 2019 exam results, Turkey was ranked 15th among 39 participants with an average score of 515 at the eighth-grade level in science and 20th among 39 participants with an average score of 496 at the eighth-grade level in mathematics (Ministry of Education [MoE], 2020). While Turkey is above the TIMSS midpoint (500 points) for science, it is below the TIMSS midpoint for mathematics.

Determining and examining the factors that affect students' mathematics and science achievement is essential to increasing their success in these subjects. Exploring the potential effect of learning factors might provide a new perspective to enhance students' mathematics and science achievements. Numerous researchers in the field of education have developed theoretical frameworks that seek to describe the relationships between various learning factors and the academic results of students (Bennett, 1978; Carroll, 1963; Glaser, 1976; Walberg, 1981). The theory of educational productivity, developed by Walberg (1981), is one of those theories. It was tested empirically and stands out as a comprehensive theory concerning academic success (Arıkan, 2016; Rugutt & Chemosit, 2005; Topcu et al., 2016). Therefore, in this study, we used Walberg's (1981) theory of educational productivity when identifying the important factors affecting students' achievement. This theory offers nine factors under three groups to develop students' affective, behavioral, and cognitive learning (Walberg, 1984). These three groups are student aptitude, instruction, and environment. The predictors of this study were selected among those three groups.

Large-scale assessments provide data about students' achievement and other essential variables such as students' attitudes, socioeconomic status, family characteristics, and home and school resources (e.g., TIMSS 2019). Several studies have examined the factors that affected students' science and mathematics achievement by considering the data from large-scale assessments such as the Programme for International Student Assessment (Demir & Kılıç, 2010; Ozel et al., 2013). However, limited studies have used TIMSS data to predict both mathematics and science achievement using the same variables. When the literature is reviewed, many studies investigate potential factors that predict students' mathematics and science achievements separately (e.g., Arikan et al., 2020; Lay & Chandrasegaran, 2016). However, predicting mathematics and science achievement with the same variables and data might be vital to obtain a holistic perspective on student achievement in Turkey. Combining and connecting different subjects within the same context is also recommended as an interdisciplinary approach in education to provide sustainable development for students (UNESCO, 2005). The importance of the integration of science and mathematics teaching and learning was emphasized by Berlin (1991): "Philosophically and theoretically, there is strong support for the integration of science and mathematics teaching and learning as a way to improve and enrich the science and mathematics learning experiences" (p. 11). Using interdisciplinary mathematics and science approaches increases students' engagement (Schroeder et al., 2007) and motivation (Al-Mutawah et al., 2022). Additionally, this approach enhances students' achievement by increasing their positive attitudes toward learning mathematics and science (Paralikar, 2018). Therefore, the current study aims to examine the predicting power of the same variables on students' science and mathematics achievement within the same study. The present study's results are expected to provide a holistic and stimulating understanding of mathematics and science achievement for researchers, teachers, and policy-makers to support students' achievement.

Theoretical Framework

According to previous research, student, family, and school characteristics affect students' mathematics and science achievement (e.g., Topcu et al., 2016). Walberg (1984) proposed the theory

of educational productivity to examine student learning. This theory suggests nine factors under three groups to improve students' affective, behavioral, and cognitive learning (Walberg, 1984).

Many studies about student learning provide supporting evidence for the groups and factors in the theory (e.g., Arıkan, 2016; Topcu et al., 2016). One of the groups in the theory of educational productivity, student aptitude, consists of three factors: ability or prior achievement, development or age, and motivation or self-concept. These factors are related to the students themselves. Students' ability or prior achievement is measured by standardized tests, their development or age is measured by chronological age or maturation, and their motivation or self-concept is measured by tests (Bruinsma & Jansen, 2007). The second group of the theory, instruction, consists of two factors: instruction time or quantity and quality of instruction. The quantity of instruction is related to the time that students spend on their learning (Bruinsma & Jansen, 2007), while the quality of instruction is related to the content and method of the instruction (Topcu et al., 2016). These factors consist of the instructional features affecting the learning of students. The third group of the theory is an environment consisting of the four factors: home, classroom, peers, and mass media. These factors include the social-psychological environment in which students are involved. These three groups are the causes of learning and affect each other.

In this study, we chose the predictor variables based on the groups of the theory of educational productivity. We considered the first group, student aptitude, while selecting the predictors of gender and confidence in mathematics and science. Because these predictors are related to the students, they were grouped under student aptitude. We considered the second group, instruction, while selecting the predictor of computer software. Because computer software is related to the usage of this type of technology in mathematics and science instruction, it was grouped under instruction. We considered the third group, environment, while selecting the predictors of the amount of books in the home and whether a student liked being in school. The environment group includes the factors related to home, classroom, etc. The educational resources at home, like the numbers of books were categorized under the environment, as indicated in Arikan's (2016) study. Additionally, in Topcu et al.'s (2016) study, they classified the school factor in TIMSS as an environmental variable in Walberg's (1984) model. Because of these examples, we categorized the amount of books in the home and whether a student liked being in school as predictors under the environment in the present study.

The Factors Predicting Students' Mathematics and Science Achievement

Attitude toward mathematics and science is an essential affective domain that has a crucial role in constructing students' learning (Bandura, 1994; Webster & Fisher, 2000). Researchers have stated that students' attitudes toward mathematics and science have positive, strong, and significant effects on students' mathematics and science achievements (e.g., Geesa et al., 2020; Kvedere, 2014). For example, Geesa et al. (2020) found that a positive attitude toward science predicts students' science achievement. Self-confidence in mathematics, which underlies attitude toward mathematics, is one of the most important indicators for assessing students' mathematics achievement (Kvedere, 2014). The failure and success of mathematics are generally related to the level of students' self-confidence in mathematics (Hosein & Harle, 2018) because students with high self-confidence in mathematics have low mathematics anxiety, enhancing their mathematics achievement (Feldman & Kubota, 2015). Sahin and Boztunc-Ozturk (2018) found that self-confidence had the highest effect size among the variables at the student level based on the TIMSS 2015 data. Lay and Chandrasegaran (2016), who analyzed the impact of confidence in science on Malaysian and Singaporean students' science achievement using TIMSS data, found positive correlations between the variable and science achievement in both countries. In a study on Southeast Asian and East Asian countries' student participants, it was indicated that being confident in science positively contributed to students' science achievement in most of these countries (Lay & Rajoo, 2020). The studies indicated that students' self-confidence in

mathematics is an essential predictor of explaining students' mathematics achievement with moderate and positive effects (Arıkan, 2016; Hosein & Harle, 2018).

Another factor that many studies consider in predicting students' mathematics and science achievement is gender (e.g., Kaleli-Yılmaz & Hancı, 2016; Pavešić, 2008). Lamb and Fullarton (2002) found that girls' mathematics achievement was lower than boys. A small but significant effect of gender on students' mathematics achievement was found by Azina and Halimah (2012) in TIMSS 2007. However, some studies did not find a significant effect of gender on mathematics achievement (e.g., Wiberg, 2019). A study using TIMSS 2015 data showed that gender weakly but significantly predicted science achievement in South Korea and Turkey in favor of males, but not in the United States (Geesa et al., 2020). Pavešić (2008), who compared the TIMSS 1995 and 2003 science achievements of students, found that while males have higher grades in physics and chemistry, they did not in biology according to TIMSS 1995 data. However, the difference between males and females was closed in TIMSS 2003 due to the newly applied system (Pavešić, 2008). In contrast to the previous studies' results, Al-Balushi et al. (2022) indicated that female students' mean scores in science are higher than those of male students based on TIMSS 2019 data.

One of the affective domains, the sense of school belonging, is also examined as a variable in the context of mathematics and science achievement (e.g., Kahraman, 2014; Topcu et al., 2016). The sense of school belonging is an essential factor that affects students' academic achievement (Duru & Balkıs, 2015). The studies about the effect of the sense of school belonging on mathematics achievement showed that this factor significantly predicts students' mathematics achievement (Duru & Balkıs, 2015; Topcu et al., 2016). Kahraman's (2014) analysis supported the previous result by saying that eighth graders' school belonging and science achievement have a positive relationship. However, this author found no significant contribution of school belonging to fourth-grade students' science achievement. The study, conducted by Kaya (2022) based on TIMSS 2019 data from Turkey, Singapore, and the United States, indicated that school belonging predicted science achievement significantly for eighth-grade Turkish students.

Students' achievement is not only affected by student-related factors; environmental factors should also be considered a predictor of students' mathematics and science achievement (Walberg, 2004). Studies showed that the number of books in the home significantly predicted students' mathematics and science achievement (e.g., Geesa et al., 2019; Wiberg, 2019). As the number of books in the home increases, students' mathematics and science achievement also increases (Wiberg, 2019; Wiberg & Rolfsman, 2019). Students who live in a home with more books get more opportunities to enhance their learning (Chiu & Xihua, 2008).

Compared to all the above variables, using technology in instruction was studied less in predicting mathematics and science achievement. Zhang and Wang (2020) examined the relationship between computer-based instruction and science and mathematics achievement of eighth-grade students using TIMSS 2011 and found an indirect relation for mathematics achievement, but not for science achievement. However, Antonijević (2007) found that using computers in instruction significantly affects science achievement to some extent. Cetintav et al. (2022) examined the effect of using technology in mathematics and science instructions using TIMSS 2019 data with eighth grade students. The results showed that eighth-grade students' science achievement is affected more than their mathematics achievement in using technology in lessons (Cetintav et al., 2022).

The Present Study

The purpose of this study is to examine the predictive effect of the variables of confidence in mathematics and science, amount of books in the home, gender, whether a student likes being in school, and computer software by measuring TIMSS 2019 on mathematics and science achievements of Turkish eighth-grade students.

The following research questions were answered in the present study:

- Which independent variables (confidence in mathematics, amount of books in the home, gender, whether a student likes being in school, and computer software) are significant in predicting the mathematics achievement of eighth-grade students in Turkey?
- Which independent variables (confidence in science, amount of books in the home, gender, whether a student likes being in school, and computer software) are significant in predicting the science achievement of eighth-grade students in Turkey?

Method

Sample

In this study, the data analyzed was procured from the TIMSS 2019 Turkey database. The sample selection design of TIMSS is a two-stage random sample design. In the first stage, schools are selected by considering probability proportional to their size, and in the second stage, one or two classes within these schools are selected (Martin et al., 2020). The sample of this study comprises all eighth-grade Turkish students who answered items in TIMSS 2019. At the eighth-grade level, the TIMSS 2019 exam was carried out with the participation of 4,077 Turkish students in 181 schools. In this study, we included only school principals who participated in TIMSS 2019 and their students because the items related to computer software was asked of these principals. This resulted in 1784 (918 females and 866 males) students and 72 principals for the analysis of mathematics achievement, and 1776 (920 females and 856 males) students and 72 principals for the analysis of science achievement in terms of the selected variables: confidece in mathematics/science, amount of books in the home, gender, whether a student liked being in school, and computer software.

Measures and Variables

Outcome Variables

Mathematics and science achievement tests are the main subjects that were administered to students in TIMSS 2019. Five plausible mathematics and science values were recorded for each student in TIMSS 2019, which are the mathematics and science achievement indicators in this study. The present study used all five plausible values for the representation of achievement. Therefore, the study's dependent variables are the mathematics and science achievements of eighth-grade Turkish students in TIMSS 2019.

Predictor Variables

The definitions and items of predictor variables in the TIMSS 2019 scales are explained below.

Students' confidence in mathematics and science. This factor refers to how well students think they can do in mathematics and science (Mullis et al., 2020). The variable of students' confidence in TIMSS takes place under the heading of students' attitudes, with students like learning and student value.

Nine items for mathematics and eight items for science were asked of students on scales. Items of scale are given in Table 1. A 4-point Likert-type scale was used to measure students' confidence in Mathematics/Science. The options for the items are "Agree a lot (coded as 1), "Agree a little (coded as 2)", "Disagree a little (coded as 3)" and "Disagree a lot (coded as 4)". For the positive items, reverse

coding was used as "Disagree a lot (coded as 1)" to "Agree a lot (coded as 4). Items coded reversely were stated at Table 1.

Table 1

Items of Students Confidence in Mathematics/Science Scale with Codes

Mathematics	Science
*I usually do well in mathematics.	*I usually do well in science.
Mathematics is more difficult for me than for many of my classmates.	Science is more difficult for me than for many of my classmates.
Mathematics is not one of my strengths.	Science is not one of my strengths.
*I learn things quickly in mathematics.	*I learn things quickly in science.
*I am good at working out difficult mathematics problems.	*I am good at working out difficult science problems.
*My teacher tells me I am good at mathematics.	*My teacher tells me I am good at science.
Mathematics is harder for me than any other subjects.	Science is harder for me than any other subjects.
Mathematics makes me confused.	Science makes me confused.
Mathematics makes me nervous.	

Note. *Reverse-coded items.

Amount of books in the home. This factor is one of the items on the home educational resources scale. The options for the number of books in the home are "none or very few (0-10, coded as 1)", "enough to fill one shelf (11-25, coded as 2)", "enough to fill one bookcase (26-100, coded as 3)", "enough to fill two bookcases (101-200, coded as 4)", and "enough to fill three or more bookcases (more than 200, coded as 5)".

Gender. Students were asked, "Are you female (coded as 1) or male (coded as 2)?" as demographic information, and students were expected to select one of the options. The baseline group of the gender variable was female students. Thus, a significant positive correlation of gender with a variable shows that males demonstrated significantly higher scores than females on that variable or vice versa.

Like being in school. The items of the sense of school belonging scale were asked of students about their attitudes toward school (Mullis et al., 2020). In this study, a 4-point Likert-type item, "I like being in school", was analyzed. The options for the items are "Agree a lot (coded as 1), "Agree a little (coded as 2)", "Disagree a little (coded as 3)" and "Disagree a lot (coded as 4)".

Computer Software. The item of "Computer software/applications for mathematics/science instruction" under the resources for mathematics and science instruction was asked to principals. This scale is a 4-point Likert-type item including "not at all (coded as 1)", "a little (coded as 2)", "some (coded as 3)", and "a lot (coded as 4)" options.

Data Source

In this current study, the TIMSS 2019 data of Turkey was used to examine the predictive power of five variables, confidence in mathematics/science, amount of books in the home, gender, whether a student liked being in school, and computer software, on mathematics and science achievements of Turkish eighth-grade students. TIMSS is one of the most popular and comprehensive large-scale assessments, and it assesses students' knowledge and skills in mathematics and science in the fourth and eighth grades. In TIMSS, the contents of mathematics and science frameworks are formed by considering the current curricula and standards of the participating countries. For both frameworks, there are two dimensions: the content domain, which specifies the subject matter for the corresponding grade, and the cognitive domain, which specifies the thinking processes of students

(Mullis & Martin, 2017). The content domains of mathematics for eighth-grade are numbers, algebra, geometry, and data and probability, while the content domains of science are biology, chemistry, physics, and earth science. There are three mathematics cognitive domains, knowing, applying, and reasoning, while there are three science cognitive domains, knowing, applying, and reasoning, to assess students' cognitive skills in TIMSS.

The Procedure for Data Analysis

In this study, two separate multiple regression analyses were conducted to predict the effects of independent variables on mathematics and science achievement. Multiple regression analysis is used to investigate the relationship between more than one predictor variable and an outcome variable. The relatively important predictor variables, that come from the literature, were determined and used to identify students' science and mathematics achievement (e.g., Duru & Balkıs, 2015; Geesa et al., 2020; Kaleli-Yılmaz & Hancı, 2016; Kvedere, 2014; Pavešić, 2008; Wiberg & Rolfsman, 2019; Zhang & Wang, 2020). In this study, confidence in mathematics, gender, the amount of books in the home, technology in instruction, and sense of school belonging as important variables were used to predict students' mathematics achievement. Similarly, to predict students' science achievement, confidence in science, gender, the amount of books in the home, technology in instruction, and sense of school belonging variables were used.

In large-scale assessments, it is impossible to include the entire population in the study; therefore, the main aim of TIMSS is to select the most representative sample that can be generalized to the population (Arıkan et al., 2020). In this point, sampling weight is the most known way to solve the problem resulting from the characteristic differences between the sample and the population (Rust, 2013). To avoid this problem, sample weight is used in TIMSS. Another critical point in TIMSS data is plausible values. The large-scale assessment aims to identify the performance of the entire population, not individuals (Monseur & Adams, 2009). Also, each student does not answer all items, but all items are answered as a group. Therefore, in TIMSS data, students' achievement scores are given five plausible values. The aim of assigning plausible values is to decrease the measurement error (Laukaityte & Wiberg, 2017). Therefore, the analysis of TIMSS data, the softwares that take into account sample weights and plausible values should be used. The International Database Analyzer (IDB Analyzer), developed by The International Association for the Evaluation of Educational Achievement (IEA), can analyze TIMSS data by considering sampling weights and plausible values (IEA, 2022). When using IDB Analyzer for regression analyses with plausible values as the dependent variable, the regression is first conducted separately for each plausible value. The results are then combined following the Rubin–Shaffer rules (Rutkowski et al., 2010).

The IDB Analyzer comprises the Merge Module and Analysis Module (IEA, 2022). Firstly, the Merge Module was used to combine files from student backgrounds and school backgrounds. Before conducting multiple linear regression, the assumptions of normality, linearity, homoscedasticity, independence of residuals, multicollinearity, and singularity were checked, and no violation of these assumptions was found. To create a good regression model, checking the relationship among independent variables and between a dependent variable and independent variables is required. As desired to conduct regression, while the relationships between the dependent variable and independent variables were high, the relationships among independent variables were low. Then, the merged data was used to conduct multiple linear regression using the Analysis Module. When the Analysis Module was run, it produced Statistical Package for the Social Science (SPSS) syntax. Then, running this syntax gave results of multiple linear regression as an SPSS output.

Results

This part of the current study comprises descriptive statistics, correlations among all variables, and the result of multiple linear regressions on mathematics and science achievement.

Descriptive Statistics and Correlations

Descriptive statistics for study variables, such as the amount of books in the home, whether a student liked being in school, computer software, and student confidence in mathematics and science, are given in Table 2.

Table 2

Descriptive Statistics of Predictor Variables for Mathematics and Science

	Mathematics					Science				
	n	**Min.**	**Max.**	***M***	**SD**	***n***	**Min.**	**Max.**	***M***	**SD**
Amount of books in the home	1784	1	5	2.66	1.15	1776	1	5	2.66	1.15
Like being in school	1784	1	4	1.67	0.82	1776	1	4	1.66	0.81
Computer software	1784	1	4	2.91	0.70	1776	1	4	3.03	0.69
Student confidence in mathematics/science	1784	9	36	21.57	3.80	1776	8	32	19.52	3.46

According to Table 2, the mean score of the variable "amount of books in the home" is 2.66 for both mathematics and science groups. This mean score falls between the categories "enough to fill one shelf (11-25)" and "enough to fill one bookcase (26-100)" on the Likert scale used in the study. Importantly, the mean score is closer to the "enough to fill one bookcase (26-100)" category. The proximity of the mean score to the higher category implies that a significant proportion of the eight-grade Turkish students likely have between 26 to 100 books at home. The mean score of the "like being in school" variable for the mathematics group is 1.67, and for the science group is 1.66. Both mean scores fall between the "Agree a lot" and "Agree a little" categories. According to the mean scores, it can be said that eighth-grade Turkish students generally have a positive attitude towards school.

While the mean score of the "computer software" variable in the mathematics group, 2.91, falls between the "a little" and "some" categories, the mean score of the variable for the science group, 3.03, falls between the "some" and "a lot" categories. Additionally, the mean scores for each group are closer to the "some" category, indicating that, on average, school principals stated the inadequacy of computer software as somewhat affecting their school's capacity to provide instruction in mathematics and science. Lastly, the mean scores of the "student confident in mathematics" and "student confident in science" variables are 21.57 and 19.52, respectively. These mean scores fall between the "Disagree a little" and "Agree a little" categories on Likert-type scale. Therefore, on average, eighth-grade Turkish students have moderate confidence in their abilities in both mathematics and science.

Table 3 shows correlations among gender, amount of books in the home, whether a student liked being in school, computer software, student confidence in mathematics, and mathematics achievement. All correlation coefficients among independent variables were small or small to medium based on cutoff values recommended by Cohen (1988). There was a statistically significant and small

relationship between whether a student liked being in school and gender, $r = .13$, which indicated that boys liked being in school more than girls. Additionally, a statistically significant positive and small to medium relationship was found between the amount of books in the home and how much students like being in school ($r = .15$) and student confident in mathematics ($r = .18$). The correlation coefficients between the dependent variable (mathematics achievement) and two of the independent variables (amount of books in the home and student confidence in mathematics) were medium to large, while the correlation coefficients between the dependent variable and the other independent variables were small (Cohen, 1988).

Table 3

Correlation Coefficient Between All Variables for Mathematics

Independent Variables	1	2	3	4	5	6
1. Gender	-					
2. Amount of books in the home	-0.10*	-				
3. Like being in school	0.13*	0.15*	-			
4. Computer software	0.00	-0.06*	-0.04	-		
5. Student confident in mathematics	0.02	0.18*	-0.15*	-0.05*	-	
6. Mathematics achievement	-0.02	0.43*	0.13*	-0.13*	0.44*	-

Note. * Statistically significant t values at $p<.05$ level.

Table 4 shows correlations among gender, amount of books in the home, whether a student liked being in school, computer software, student confidence in science, and science achievement. All correlation coefficients among independent variables were small or small to medium based on cutoff values recommended by Cohen (1988).

Table 4

Correlation Coefficient Between All Variables for Science

Independent Variables	1	2	3	4	5	6
1. Gender	-					
2. Amount of books in the home	-0.10*	-				
3. Like being in school	0.14*	0.15*	-			
4. Computer software	-0.03	-0.11*	-0.11*	-		
5. Student confident in science	0.04	0.18*	-0.12*	0.05*	-	
6. Science achievement	-0.03	0.41*	0.14*	-0.14*	0.43*	-

Note. * Statistically significant t values at $p<.05$ level.

In this analysis, there was a statistically significant and small to medium relationship between the variables like being in school and gender, $r = .14$. Additionally, a statistically significant positive and small to medium relationship was found between the amount of books in the home and how much students like being in school ($r = .15$) and student confident in science ($r = .18$). The correlation coefficients between the dependent variable (science achievement) and two of the independent variables (amount of books in the home and student confidence in science) were medium, while the correlation coefficients between the dependent variable and the other independent variables were small (Cohen, 1988).

The Results of Multiple Linear Regressions

Multiple regression analyses were conducted to identify which independent variables significantly predict Turkish students' mathematics and science achievement in TIMSS 2019 See Table 5 for these results.

Table 5

Multiple Linear Regression Results for Mathematics and Science Achievement

Variable	Mathematics			Science		
	B	***β***	***t***	**B**	***β***	***t***
Gender	-9.55	-.05	-1.23	-12.13	-.06	-1.74
Amount of books in the home	-34.99	-.15	-6.35*	-31.56	-.15	-4.97*
Like being in school	34.12	.16	4.93*	41.45	.21	6.97*
Computer software	1.35	.01	.08	-1.18	.00	-.08
Student confidence in mathematics /science	19.67	.44	13.77*	20.15	.44	14.19*

Note. * Statistically significant t values at $p<.05$ level.

The result of multiple regression analysis indicated that the overall model, used to predict Turkish students' mathematics achievement in TIMSS 2019 by using five predictor variables, was found statistically significant, $R^2 = .24$, and $p<.01$. Among five independent variables, three of them, the amount of books in the home, whether a student liked being in school, and confidence in mathematics, had statistically significant contributions in Turkish students' mathematics achievement after controlling for the other predictors (see Table 5). The model explained 24% of the variance in Turkish students' mathematics achievement in TIMSS 2019, which corresponds to a medium to large effect size (Cohen, 1988). However, the other two variables, gender and computer software, had no statistically significant predictive power on students' mathematics achievement in TIMSS 2019 after controlling for the other predictors.

To compare the contribution of significant predictive variables on students' mathematics achievement, the standardized β weights were considered. The significant positive β weights stated that Turkish students with higher scores in whether they liked being in school and confidence in mathematics tended to have higher mathematics achievement in TIMSS 2019. However, the significant negative β weight stated that Turkish students with higher scores in the amount of books in the home tended to have lower mathematics achievement in TIMSS 2019. When the contribution amounts of independent variables are examined, it can be seen that except for students' confidence in

mathematics, all other variables were a small to medium in predicting students' mathematics achievement (Cohen, 1988). Students' confidence in mathematics variable has a medium to large level of contribution to predicting students' mathematics achievement after controlling for the other predictors (Cohen, 1988). Even if the correlation coefficient between mathematics achievement and the variables, amount of books in the home and student confidence in mathematics, were almost equal, the regression results showed that the contribution of these two independent variables to mathematics achievement were not the same. Though two independent variables were significant in predicting student mathematics achievement, the variable, amount of books in the home, was found to be lower than student confidence in mathematics in predicting their mathematics achievement. Among all independent variables, the standardized β weight of students' confidence in mathematics was highest; therefore, it can be said that students' confidence in mathematics made the largest contribution to predicting Turkish students' mathematics achievement in TIMSS 2019 after controlling for the other predictors.

Multiple regression analysis showed that the overall regression models predicting science achievement from indices were statistically significant for Turkish students, $R^2 = .26$ and $p<.01$. Among five predictor variables, three of them, amount of books in the home, whether a student liked being in school, and student confidence in science, had statistically significant contributions in predicting TIMSS 2019 science achievement after controlling for the other predictors (see Table 5). The model explained 26 % of the variance in the Turkish students' science achievement in TIMSS 2019, corresponding to a large effect size. On the other hand, the variables of gender and computer software had no statistically significant predictive effects on students' science achievement after controlling for the other predictors.

To compare the contribution of significant predictive variables on students' science achievement, the standardized β weight was considered. The significant positive β weights of each predictor variable show that students with a higher score in TIMSS 2019 show higher scores in like being in school and student confidence in science. On the other hand, the significant negative β weight indicated that students with a higher score in TIMSS 2019 show lower scores in the variable, amount of books in the home. When the contribution amounts of independent variables are examined, it can be seen that, except students' confidence in science, the variables amount of books in the home and like being in school, were a small to medium in predicting students' science achievement (Cohen, 1988).

Even if the correlation coefficient between science achievement and the variables, amount of books in the home and student confidence in science were almost equal, the regression results showed that the contribution of two independent variables on science achievement were not the same. Though two independent variables were significant in predicting student science achievement, the variable, amount of books in the home, was found to be lower than student confidence in predicting their science achievement. The value of students' confidence in science is the highest and it has a medium to large level of contribution for predicting students' science achievement after controlling for the other predictors (Cohen, 1988). Thus, students' confidence in science had the largest value in predicting Turkish students' science achievement in TIMSS 2019 after controlling for the other predictors.

As a result of the current study, the analyses conducted for mathematics and science achievement gave similar descriptive and inferential results. The regression results showed that the same independent variables, the amount of books in the home, like being in school, and confidence in mathematics/science, had statistically significant predictor power on students' mathematics and science achievement. Even if R^2 of the regression model for science achievement ($R^2 = .26$) was higher than R^2 of the regression model for mathematics achievement ($R^2 = .24$), the explained variability on mathematics and science achievement is close to each other. Lastly, the unique contributions of significant predictor variables on students' mathematics and science achievement also showed

similarities. According to their standardized β weights, it can be seen that students' confident in mathematics/science made the largest contribution to predicting Turkish eighth-grade students' mathematics and science achievement in TIMSS 2019.

Discussion and Conclusion

Research about mathematics and science achievement indicated that affective variables are strong predictors of mathematics and science achievement in large-scale assessments (e.g., Duru & Balkıs, 2015; Geesa et al., 2020; Kvedere, 2014). In the current study, confidence in mathematics/science is a variable that has a larger positive contribution than other variables in the mathematics and science achievement of students in Turkey. This means that being confident in mathematics/science is strongly related to achievement in mathematics and science. The literature also supports this result for science (e.g., Lay & Chandrasegaran, 2016) and mathematics (e.g., Arıkan, 2016). Because students with high self-confidence tend to be less anxious and less hesitant to engage in learning (Coskun & Karakaya-Ozyer, 2023), it is expected that there is a positive relationship between students' confidence in mathematics/science and their achievement in mathematics and science. By means of this bidirectional relationship, increasing students' confidence in mathematics/science might foster their learning process (Akbari & Sahibzada, 2020). At this point, the role of teachers is significant to provide students with opportunities to have and maintain positive beliefs about mathematics and science abilities. Therefore, the strategies teachers apply in class are among the most important factors shaping students' confidence levels in mathematics/science (Akyuz, 2014). One of the strategies is to design learning tasks that students can achieve while working on these tasks (Akyuz, 2014). Thus, teachers should be aware of the importance of students' confidence levels and build their instruction considering this perspective.

According to the multiple linear regression results for the TIMSS 2019 data, when eighth grade Turkish students liked being in school, their academic achievement in mathematics and science increased. Kaya (2022) also found a similar result for science achievement using a different regression model with the same data for eighth-grade Turkish students in TIMSS 2019. The TIMSS 2011 data analysis results similarly indicated that school belonging and science achievement positively correlated for eighth graders (Kahraman, 2014). In common with the science literature, studies indicated that the variable, like being in school, is also a significant predictor of students' mathematics achievement (Duru & Balkıs, 2015; Topcu et al., 2016). Students who like being in school tend to obtain higher scores in mathematics (Topcu et al., 2016). The reason for the positive relationship between students' academic achievement and the variable like being in school might come from the nature of learning. Sociocultural theory emphasizes that learning takes place in a social context and cannot be explained without taking into account students' social interactions with each other and teachers (Kyungsoon, 2000). When students feel they belong in the school, they can construct a community with shared interests and features to build learning (Osterman, 2000). Therefore, considering the critical predictive power of the variable like being in school, it would be crucial to enhance students' sense of school belonging by providing opportunities to make them feel like a member of the school community.

The results of the present study indicated that the correlation coefficients between mathematics/science achievement and the amount of books in the home were statistically significant and medium to large. Previous studies have also supported these positive relationships (e.g., Geesa et al., 2019; Wiberg & Rolfsman, 2019). The studies of Geesa et al. (2019) and Wiberg and Rolfsman (2019) showed that the amount of books in the home contributed positively to students' science achievement. Similar to science achievement, it was found that there is a positive predictive power of the amount of books in the home on students' mathematics achievement (Wiberg, 2019). Although related literature states that students with more books in the home are more likely to succeed in mathematics/science (Wiberg, 2019), regression results of the current study showed that even if the

amount of books in the home is one of the statistically significant predictors for mathematics and science achievement, the contribution of the variable was negative and small after controlling for the other predictor variables. The results showed that when other predictor variables are controlled, the amount of books in the home is not a positive predictor of explaining mathematics and science achievement. That means if students' confidence in mathematics/science had been similar, then the relationship between the amount of books in the home, one of the socio-economic indicators of the student, and students' mathematics and science achievement would be insignificant. Thus, the impact of such socio-economic variables, which are much more difficult to control and change, on mathematics and science achievement can be reduced by supporting student confidence in mathematics/science in the classroom. Equality in education can be achieved for students from different socio-economic environments.

Even though the literature showed that there are significant differences between female and male students in mathematics (e.g., Kaleli-Yılmaz & Hancı, 2016) and science achievement in TIMSS (e.g., Al-Balushi et al., 2022; Geesa et al., 2020), the present study did not find a significant difference between gender. This means that gender is not one of the predictors of eighth-grade Turkish students' mathematics and science achievement based on the results of TIMSS 2019. However, Geesa et al. (2020) found a difference between gender in favor of male students on science achievement by analyzing the TIMSS 2015 data of Turkey. The reason for finding no difference between genders in the present study can be that gender inequality toward science has decreased with time in Turkey. Similar inferences can also be made for Turkish students' mathematics achievement. Previous studies indicated a difference in students' mathematics achievement according to their genders, and boys generally tend to get higher mathematics scores than girls. According to Kaleli-Yılmaz and Hancı (2016), in TIMSS 2011, gender is a significant predictor of students' mathematics achievement. However, recent studies showed that the gender gap in students' mathematics achievement has started to close (e.g., Wilberg, 2019). Therefore, it might have been found that in the current study, gender is not a significant predictor of Turkish students' mathematics achievement in TIMSS 2019.

Using technology-integrated instruction in classrooms is an increasing trend in mathematics and science education (Zhang & Wang, 2020). Studies focusing on the effects of technology-integrated instruction on mathematics and science achievement presented different results for both subjects (e.g., Antonijević, 2007). For example, while some studies found a positive relationship between the use of technology in instruction and students' mathematics/science achievement (Antonijević, 2007; Zhang, 2018), Cetintav et al. (2022) found that eighth-grade students' science achievement is affected more than their mathematics achievement during the usage of technology in instruction.

In this study, it was expected that the computer software variable would significantly predict students' mathematics and science achievement, with a higher contribution level to science achievement. However, the results showed that the achievement in both subjects is not affected by the deficiency of computer software in schools, even though Turkish school principals stated the inadequacy of computer software as somewhat affecting their school's capacity to provide instruction in mathematics and science. This result raises the question of the extent to which computer software is used in mathematics and science instruction systematically because an effective use of technology creates a difference in students' academic achievement by providing them with various learning opportunities (Ma et al., 2014). Therefore, it would be beneficial to examine why the shortage of computer software did not predict eighth-grade Turkish students' mathematics and science achievement in TIMSS 2019. This might be related to teachers' competence and abilities to use computer software during their instruction because teachers' competencies to use technology is an essential factor for the effectiveness of computer-integrated instruction (Gorder, 2008). In other words, Turkish mathematics and science teachers may not be able to properly use computer software during instruction, which might prevent seeing the effect of computer software on students' academic achievement in TIMSS 2019. Another reason for the non-significant result might be related to

students' engagement in activities conducted using computers (Tas & Balgalmis, 2016). To increase the effectiveness of using computers in mathematics/science achievement, teachers can give more opportunities to be included in activities conducted with computers (Tas & Balgalmis, 2016).

To sum up, addressing only content knowledge might not be adequate to increase achievement in mathematics and science. There are various factors regarding students, schools, and home background that can have an impact on students' achievement (Walberg, 1984). As a result of the current study, independent variables that predict mathematics and science achievement show similarities in their contribution levels. These predictor variables, confidence in mathematics/science, whether a student liked being in school, and the amount of books in the home, can be considered general factors to explain students' achievement that the authorities should consider to enhance students' learning. The current study has some recommendations for decision-makers to increase students' success in science and mathematics in Turkey. According to the present study, affective variables such as confidence in mathematics/science and whether a student liked being in school are significant predictors of achievement. Thus, decision-makers should work with school principals, teachers, etc., and engage in activities to make students more confident in subjects and feel a sense of belonging in school. For future studies, the researchers might use different theoretical frameworks, including different variables, to predict students' achievement in mathematics and science. Researchers also might conduct systematic literature review studies that investigate variables to predict achievement in mathematics and science of Turkish students in TIMSS to reveal trends in literature. Additionally, researchers may prefer to use Structural Equation Modeling to analyze direct and indirect relations of predictors of academic achievement.

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