

Factors Influencing Science Achievement in Turkey in TIMSS 2015 and 2019*

Article Type	Received Date	Accepted Date
Research	11.02.2025	30.07.2025

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Abstract

This study investigates the factors associated with the level of science competency among eighth-grade students in Turkey in the 2015 and 2019 cycles of the Trends in International Mathematics and Science Study (TIMSS). Using data obtained from TIMSS 2015 and 2019, the study examines relationships between factors such as educational expectations, frequency of science teachers assigning homework, sense of belonging to school, enjoyment of learning science, valuing science, and confidence in science and students' science competency levels. Data from science achievement tests and student questionnaires collected from eighth-grade students in Turkey who participated in TIMSS 2015 and 2019 evaluations were used as research instruments. The sample comprised 6,079 students included within the scope of TIMSS 2015, and 4,077 students included in TIMSS 2019 at the eighth-grade level. Logistic regression analyses were performed for the obtained data with results demonstrating that factors such as educational expectations and confidence in science had strong positive relationships with the students' science competency. In contrast, factors including the frequency of science teachers assigning homework, sense of belonging to school, enjoyment of learning science, and valuing science were found to have negative relationships with science competency levels.

Keywords: TIMSS, homework, belonging, expectations, value, confidence.

* This article was derived from the first author's master's thesis entitled "Investigation of students' science competency levels and socioeconomic status in TIMSS with regard to some variables" supervised by the second author.

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TIMSS 2015 ve 2019'da Türkiye'de Fen Başarısını Etkileyen Faktörler *

Makale Türü	Başvuru Tarihi	Kabul Tarihi
Araştırma	11.02.2025	30.07.2025

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Öz

Bu çalışma, Uluslararası Matematik ve Fen Eğilimleri Araştırması'nın (TIMSS) 2015 ve 2019 döngülerinde Türkiye'deki sekizinci sınıf öğrencilerinin fen yeterlilik düzeyleriyle ilişkili faktörleri araştırmaktadır. Çalışma, TIMSS 2015 ve 2019'dan elde edilen verileri kullanarak, eğitim beklentileri, fen öğretmenlerinin ödev verme sıklığı, okula aidiyet duygusu, fen öğrenmekten keyif alma, fene değer verme ve fene güven gibi faktörler ile öğrencilerin fen yeterlilik düzeyleri arasındaki ilişkileri inceliyor. Araştırma aracı olarak TIMSS 2015 ve 2019 değerlendirmelerine katılan Türkiye'deki sekizinci sınıf öğrencilerinden toplanan fen başarı testleri ve öğrenci anketlerinden elde edilen veriler kullanılmıştır. Örneklem, sekizinci sınıf düzeyinde TIMSS 2015 kapsamında yer alan 6.079 ve TIMSS 2019 kapsamında yer alan 4.077 öğrenciden oluşmaktadır. Elde edilen veriler için lojistik regresyon analizleri yapılmış ve sonuçlar, eğitim beklentileri ve fene duyulan güven gibi faktörlerin öğrencilerin fen yeterlilikleri ile güçlü pozitif ilişkilere sahip olduğunu göstermiştir. Buna karşılık, fen öğretmenlerinin ödev verme sıklığı, okula aidiyet duygusu, fen öğrenmekten keyif alma ve fene değer verme gibi faktörlerin fen yetkinlik düzeyleri ile negatif ilişkiye sahip olduğu bulunmuştur.

Anahtar Sözcükler: TIMSS, ev ödevi, aidiyet, beklenti, değer, güven.

* Bu makale, ilk yazar tarafından ikinci yazarın danışmanlığında hazırlanan "TIMSS'te öğrencilerin fen yeterlik seviyelerinin ve sosyoekonomik durumlarının bazı değişkenler bağlamında incelenmesi" başlıklı yüksek lisans tezinden derlenmiştir.

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Introduction

Science achievement is of great significance because of its effects on individuals' future careers and occupational choices. There are various factors that influence science achievement. These factors include students' motivations, educational resources, socioeconomic status, the frequency of homework, the sense of belonging to school, and educational expectations (Fan, Xu, Cai, He, & Fan., 2017; Zhang, Bae, & Broda, 2022; Pongsophon, 2023). Data from Trends in International Mathematics and Science Study (TIMSS) have revealed that countries in which students have a greater sense of belonging to school, enjoy and value science learning, and have confidence in science learning tend to have better science outcomes (Lay & Chandrasegaran, 2016; Lay & Ng, 2021).

Research conducted in the United States has shown that parent-student communication and high parental expectations are associated with student achievement (Martin, Mullis, Foy, & Stanco, 2012). Among different ethnic groups, parents' expectations for higher education were the strongest predictor of students' own expectations, which positively influenced their academic performance (Martin et al., 2012). Consequently, students with high educational expectations scored higher in science than students with low expectations (Chi & Wang, 2023).

According to TIMSS data, the frequency and types of homework vary widely across countries (Martin et al., 2012). For example, in countries such as Kazakhstan, Iran, and Thailand, teachers assign more science homework to eighth-grade students, while teachers in countries such as Norway, Sweden, and Denmark assign less homework (Fensham, 2013). In Latin America, homework frequency has a clearer impact on academic performance than the amount of homework given (Fernández-Alonso et al., 2019). Teachers' homework assignment practices are influenced by various factors such as class size, socioeconomic status, and geographical region (Bowd, Bowles, & McKenzie, 2021).

Another important factor affecting students' science achievement is their sense of belonging to school. Research shows that students' sense of belonging to school is directly related to their academic performance (Abdollahi & Noltemeyer, 2018; Atabey, 2020). Positive relationships between teachers and students have also been observed to increase the student's sense of belonging and, consequently, achievement (Arends & Visser, 2019; Avcı & Çakır, 2021). However, it is emphasized in the literature that the sense of belonging may differ according to demographic factors such as socioeconomic level and gender; therefore, these factors should be considered in education systems (Hughes, Im, & Allee, 2015).

Students' science-related attitudes and self-confidence also have a significant impact on science achievement (Baş, Şentürk, & Cığerci, 2016; Juan, Hannan, & Namome, 2018; Aguilera & Perales-Palacios, 2020). Moreover, possessing self-efficacy in science, valuing science, and enjoying their courses have determining effects on students' academic achievement (Grabau & Ma, 2017; Cohen & Chang, 2018). Self-confidence in science has a positive relationship with students' academic achievement; students with high self-confidence generally achieve better results (Mao, Cai, He, Chen, & Fan, 2021; Çıracı, Akpınar, & Çelik, 2024). In contrast, low self-confidence can cause students to develop negative attitudes towards science courses (Sheldrake, 2016).

Studies on TIMSS applications have examined the variables that affect students' science achievement. They have also explored the components of science literacy and students' performances in relevant sub-areas. The results showed that students performed better with questions about general knowledge and life science, but they had lower levels of success for questions that involved applying that knowledge or physical science (Türkmen & Benzer, 2023). These results suggest that, in addition to individual and contextual factors affecting science proficiency levels, cognitive and subject-area proficiency levels should also be considered (Yılmaz & Sarı, 2023).

Research conducted with TIMSS data has shown that teacher-related factors influence student achievement as well. For example, Aydın Gürler (2023) revealed that most teachers had limited knowledge of the scope and structure of TIMSS assessments, but the increased success in 2019 was attributed to pedagogical and technological transformations in education. These findings suggest that teacher competencies and assessment awareness may be decisive factors in international achievement

levels. In summary, science achievement is a multidimensional concept shaped by not only student characteristics but also teacher qualifications, school climate, and social factors.

Significance of the Study

This study is of importance as it examines the differences between groups of students with lower and higher achievement in science in Turkey, with a particular focus on analyzing data from TIMSS 2015 and 2019 cycles. Understanding whether trends in science achievement remain stable or change over time is critical for developing effective educational policies. This study emphasizes two main dimensions of science achievement. First, it investigates whether the effects of variables that predict students' science achievement, such as expectations for further education, the frequency of homework assignments given by science teachers, and students' sense of belonging to school, have changed over the years. Second, it provides insight into how these factors contribute to gaps in achievement. By examining these factors, the study offers guidance for targeted interventions aimed at improving science education outcomes for all students. The importance of this research therefore lies in its focus on longitudinal trends in science achievement.

Research Questions

This study explores how students' expectations for further education, science teachers' frequency of homework assignments, having a sense of belonging to school, enjoying science learning, valuing science, and being confident in science are related to science competency levels. This study also considers whether levels of science achievement have stayed the same or changed over time, comparing the results from TIMSS 2015 and 2019. Thus, the study aims to answer the following questions:

- 1) Is there a relationship between students' expectations for further education, the frequency of homework assignments given by science teachers, students' sense of belonging to school, whether students enjoy learning science or not, whether students value science, or students' confidence in science and competency groups among students in Turkey according to TIMSS 2015 results?
- 2) Is there a relationship between students' expectations for further education, the frequency of homework assignments given by science teachers, students' sense of belonging to school, whether students enjoy learning science or not, whether students value science, or students' confidence in science and competency groups among students in Turkey according to TIMSS 2019 results?

Method

Research Design

In this study, possible relationships between the science competency groups of eighth-grade students in Turkey and these students' educational expectations, frequency of homework assignments given by science teachers, sense of belonging to school, enjoyment of learning science, valuing of science, and confidence in science were evaluated by logistic regression analysis and the obtained data were compared over time.

Research Sample

The research sample was selected using a two-stage stratified sampling procedure developed by the International Association for the Evaluation of Educational Achievement (IEA). First, schools were randomly selected, followed by a random selection of classes within those schools. The sample included 6,079 students in 238 schools in Turkey for TIMSS 2015 and 4,077 students in 181 schools in Turkey for TIMSS 2019.

Data Collection and Research Instruments

Data were obtained from the official website of the IEA, which collects information from TIMSS student surveys. These surveys include science achievement tests and questionnaires administered to students in the eighth grade in Turkey during TIMSS 2015 and 2019 cycles. Data from TIMSS 2015 and 2019 were used according to the respective methodologies described on the IEA's official website.

TIMSS surveys asked students to specify the level of education they expected to achieve. Students were also asked how often their science teachers gave homework according to a rating scale ranging from 1 to 5 (1: “every day,” 5: “never”). The students’ sense of belonging to school was also studied with their responses grouped into one of three categories: “high sense of belonging,” “sense of belonging,” and “little sense of belonging.” Students also rated their interest in, their valuing of, and their confidence in science in TIMSS 2015 and 2019 surveys on a 4-point scale. High scores from these scales indicated positive attitudes towards science.

Validity and Reliability

The scales used in the present study were checked for reliability and validity. The item factor loadings of the scales for school belonging, enjoyment of science learning, valuing of science, and self-confidence in science were all above 0.32, ranging from 0.52 to 0.86. These scales also had good reliability as reflected by Cronbach alpha values above 0.7. However, for TIMSS 2015 and 2019, the explained variance ratios of the self-confidence and school belonging scales were below 50%. The ratios for enjoying science learning and valuing science were at acceptable levels.

Data Analysis

This study used logistic regression to determine which factors affected the science skills of eighth-grade students in Turkey. To answer the first research question, we conducted multiple regression analysis of different factors potentially affecting students’ science achievement in TIMSS 2015 in Turkey. To control for other factors, we considered students’ expectations for further education, the frequency of homework assignments, students’ sense of belonging to school, whether students enjoyed learning science or not, whether students valued science, and the students’ confidence in science. The model used to address the first question was as follows:

$$\Pr(\text{Competency Groups of Students}_{\text{TIMSS15}} = 1) = \frac{\exp(\beta_0 + \beta_1 \text{Expect}_{\text{TIMSS15}} + \beta_2 \text{Homework}_{\text{TIMSS15}} + \beta_3 \text{Belong}_{\text{TIMSS15}} + \beta_4 \text{Enjoy}_{\text{TIMSS15}} + \beta_5 \text{Value}_{\text{TIMSS15}} + \beta_6 \text{Confident}_{\text{TIMSS15}})}{1 + \exp(\beta_0 + \beta_1 \text{Expect}_{\text{TIMSS15}} + \beta_2 \text{Homework}_{\text{TIMSS15}} + \beta_3 \text{Belong}_{\text{TIMSS15}} + \beta_4 \text{Enjoy}_{\text{TIMSS15}} + \beta_5 \text{Value}_{\text{TIMSS15}} + \beta_6 \text{Confident}_{\text{TIMSS15}})}$$

The second research question addressed how students’ science achievement in TIMSS 2019 in Turkey was affected by a set of factors that included students’ expectations for further education, homework, belonging, enjoying science learning, valuing science, and confidence in science. The model for this second question was as follows:

$$\Pr(\text{Competency Groups of Students}_{\text{TIMSS19}} = 1) = \frac{\exp(\beta_0 + \beta_1 \text{Expect}_{\text{TIMSS19}} + \beta_2 \text{Homework}_{\text{TIMSS19}} + \beta_3 \text{Belong}_{\text{TIMSS19}} + \beta_4 \text{Enjoy}_{\text{TIMSS19}} + \beta_5 \text{Value}_{\text{TIMSS19}} + \beta_6 \text{Confident}_{\text{TIMSS19}})}{1 + \exp(\beta_0 + \beta_1 \text{Expect}_{\text{TIMSS19}} + \beta_2 \text{Homework}_{\text{TIMSS19}} + \beta_3 \text{Belong}_{\text{TIMSS19}} + \beta_4 \text{Enjoy}_{\text{TIMSS19}} + \beta_5 \text{Value}_{\text{TIMSS19}} + \beta_6 \text{Confident}_{\text{TIMSS19}})}$$

Results

The competency groups that served as the dependent variable for the first and second research questions were coded as follows: “very low” and “low” levels were coded as 0, while “high” and “advanced” levels were coded as 1. Competency groups were classified as very low, low, intermediate, high, and advanced based on the cut-off scores determined for international science competency levels with TIMSS 2015 and 2019 data for the respective research questions. The analysis of the present study did not include data from intermediate-level students; the data of students at low and very low levels were combined to form one group and the data of students at advanced and high levels were combined to create the other group. Analysis was performed for the first and second research questions using these two groups obtained with data on competency levels for each year of interest.

Table 1. Eighth-grade students from Turkey participating in TIMSS 2015 and 2019 according to percentages of competency groups

Competency Groups	TIMSS 2015 N = 4,195	TIMSS 2019 N = 2,931
Very low or low competency	60.5	48.8
High or advanced competency	39.5	51.2

Table 1 presents data on the numbers of eighth-grade students from Turkey who participated in TIMSS 2015 and 2019, categorized within “very low or low” and “high or advanced” competency groups. Multiple logistic regression was used to examine the effects of the selected independent variables on students’ science competency according to TIMSS 2015 and 2019 for the respective research questions. Table 2 presents the variables and accompanying odds ratios. For the categorical variable of the frequency of the science teacher assigning homework, “1-2 times a week or less than once a week or never” was coded as 0 and “3-4 times a week or every day” was coded as 1. Among the other categorical variables, educational expectation was coded as 0 for “less than undergraduate” and as 1 for “undergraduate or beyond.”

Table 2. *Estimated odds ratios for competency groups in TIMSS 2015 and 2019*

	TIMSS 2015	TIMSS 2019
Students’ Educational Expectations (1)	17.353* (0.208)	11.566* (0.189)
Frequency of Science Teacher Assigning Homework (1)	0.450* (0.082)	0.454* (0.106)
Sense of Belonging to School	0.835 (0.22)	0.863 (0.028)
Students Enjoy Learning Science	0.908 (0.030)	0.871 (0.039)
Students Value Science	0.924 (0.026)	0.932 (0.033)
Students Are Confident in Science	1.819 (0.028)	2.092 (0.039)
Constant	0.005* (0.344)	0.003* (0.433)

*, $p < 0.05$; standard errors are shown in parentheses

Interpretations of Results for the First Research Question

According to Table 2, at the eighth-grade level for TIMSS 2015, when other variables are controlled, students expecting to obtain education at the undergraduate level or beyond were 17 times more likely to be in the “high or advanced” competency group compared to those expecting to obtain a level of education lower than the undergraduate level in Turkey (OR: 17.353; CI: 11.548-26.077; $p < 0.05$). Students whose science teachers assigned homework 3-4 times or every day per week were 55% less likely to be in the “high or advanced” competency group than students whose science teachers assigned homework 1-2 times or less than once per week or never (OR: 0.450; CI: 0.383-0.527; $p < 0.05$). Students who felt more belonging to school were 16.5% less likely to be in the “high or advanced” competency group than students who felt less belonging to school (OR: 0.835; CI: 0.800-0.872; $p < 0.05$). Students who enjoyed learning science were 9.2% less likely to be in the “high or advanced” competency group than students who did not enjoy learning science (OR: 0.908; CI: 0.855-0.963; $p < 0.05$). Students who valued science highly were 7.6% less likely to be in the “high or advanced” competency group than students who valued science less (OR: 0.924; CI: 0.878-0.972; $p < 0.05$). Students with high science self-confidence were 1.8 times more likely to be in the “high or advanced” competency group than students with low science self-confidence (OR: 1.819; CI: 1.724-1.920; $p < 0.05$).

Interpretations of Results for the Second Research Question

As seen in Table 2, at the eighth-grade level for the 2019 TIMSS, when other variables are controlled, students expecting to obtain education at the undergraduate level or beyond were 11 times more likely to be in the “high or advanced” competency group compared to those expecting to obtain a level of education lower than the undergraduate level in Turkey (OR: 11.566; CI: 7.986-16.752; $p < 0.05$). Students whose science teachers assigned homework 3-4 times or every day per week were

54.6% less likely to be in the “high or advanced” competency group than students whose science teachers assigned homework 1-2 times or less than once per week or never (OR: 0.454; CI: 0.369-0.559; $p < 0.05$). Students with a high sense of belonging to school were 13.7% less likely to be in the “high or advanced” competency group than students who felt less belonging to school (OR: 0.863; CI: 0.817-0.911; $p < 0.05$). Students who enjoyed learning science were 12.9% less likely to be in the “high or advanced” competency group than students who enjoyed science less (OR: 0.871; CI: 0.807-0.940; $p < 0.05$). Students who valued science highly were 6.8% less likely to be in the “high or advanced” competency group than students who valued science less (OR: 0.932; CI: 0.873-0.995; $p < 0.05$). Students with high science self-confidence were 2 times more likely to be in the “high or advanced” competency group than students with low science self-confidence (OR: 2.092; CI: 1.937-2.259; $p < 0.05$).

Model fit was tested to evaluate the generalizability of the model. In the logistic regression model created with data from 2019, the Nagelkerke R^2 value was .475, indicating that the model’s explanatory power was moderate to high for the dependent variable. The overall classification accuracy of the model was found to be 77.4% and there was no uneven distribution of success across groups. These findings suggested that the model does not show overfitting. Similarly, using 2015 data, the Nagelkerke R^2 value was .434 and the overall accuracy rate was 77.1%. Although there are relatively significant differences between groups, it can be said that the model does not have a risk of overfitting.

To assess the risk of multicollinearity in the logistic regression model, linear regression-based collinearity analysis was performed to test whether there was multicollinearity among the independent variables and the variance inflation factor (VIF) values were examined. The VIF values of all independent variables were found to be below 5, indicating that there was no significant multicollinearity among the variables.

Discussion, Conclusion and Recommendations

In TIMSS 2015 and 2019, Turkish students in the “high or advanced” science competency group were influenced by factors including educational expectations, homework frequency, sense of belonging to school, enjoying science learning, and confidence in science. In TIMSS 2015 and 2019, educational expectation was the most predictive variable for eighth-grade students having high or advanced competency in Turkey. Self-confidence in science was also linked to better science results. Other factors including science homework frequency, sense of belonging to school, enjoying science learning, and valuing science were negatively related to students having high or advanced competency in Turkey in TIMSS 2015 and 2019.

When the literature was examined, it was seen that similar results were obtained in previous studies on the relationship between educational expectations and academic achievement. Educational expectations are associated with educational achievement, which indicates that expectations have a positive effect on achievement (Dochow & Neumeyer, 2021; Khattab, Madeeha, Samara, Modood, & Barham, 2021). International data from TIMSS also show that there is a positive relationship between students’ educational expectations and average science achievement at the eighth-grade level (Martin et al., 2012). Yıldırım, Yıldırım and Ceylan (2021) reported that educational expectations were associated with the academic achievement of Turkish students participating in TIMSS 2019. Yeung (2024) found that educational expectations and science performance were mutually predictive of each other throughout middle school. Collectively, these studies suggest that fostering positive educational expectations and aspirations can increase science achievement and future academic outcomes (Awang, Salleh, & Yoong, 2023). The higher achievement of students with higher educational expectations may be related to their career expectations related to science (Kim, 2019; Chavira, Cooper, & Vasquez-Salgado, 2016; Schneider, Kim, & Klager, 2017). Parental expectations also support students’ expectations and indirectly influence their academic achievement and goals (Froiland & Worrell, 2017). The 2015 PISA report for Turkey emphasizes that students’ science achievement increases as their future academic expectations increase. In this regard, the trend in Turkey is similar to that of other OECD countries (Ministry of National Education [MoNE], 2016).

In studies from Turkey and in the international literature, research on the effect of homework on academic achievement has yielded varying results. Some studies have shown that the relationship

between science homework and achievement is positive or is weak but statistically significant and positive (Baş, Şentürk, & Cığerci, 2017; Burriss & Snead, 2017; Fan et al., 2017; Chin, Lin, & Chen, 2020; McJames, Parnell, & O'Shea, 2024). In a modeling study using 1999 TIMSS data from Turkey, a negative relationship was found between student-centered activities and science achievement, while a positive relationship was found for teacher-centered activities (Ceylan & Berberoğlu, 2007). Data from the 2019 TIMSS showed no clear relationship between the time students spent on homework and TIMSS achievement (Mullis & Martin, 2017). Yıldırım et al. (2021) reported a negative relationship between homework frequency and the science achievement of Turkish students participating in the TIMSS in 2019. Kaya and Kaya (2018) found that students who did homework less than once a week and those who did homework for 31-60 minutes had the highest science achievement levels. The results of this study are consistent with the findings reported by Al-Bahrani, Apostolova-Mihaylova, and Marshall (2022), as the frequency of homework assignments given by science teachers had a significant negative relationship with student achievement. The negative effect of homework frequency on science achievement is often associated with the quality of the homework content and the students' individual characteristics, including motivation and time management skills (Burriss & Snead, 2017; Chin et al., 2020). Assignments should be organized in accordance with students' individual levels of understanding and their personal interests, and they should also be organized in meaningful and methodical ways (Cooper, Robinson, & Patall, 2006). Research in Turkey has also shown that factors such as students' levels of preparation and teachers' classroom approaches can influence the negative relationship between homework frequency and achievement (Yıldırım et al., 2021).

Studies in the literature generally report a positive relationship between academic achievement and school belonging (Allen, Kern, Vella-Brodrick, Hattie, & Waters, 2018; Korpershoek, Canrinus, Fokkens-Bruinsma, & de Boer, 2019). A report from the OECD (2017) also showed that a sense of belonging can increase students' academic achievement and motivation to learn. Some studies conducted in Turkey have similarly indicated that a sense of school belonging has positive effects on students' academic achievement (Yıldırım, 2017; Kalkan & Dağlı, 2021). However, the present study found that students with a high sense of school belonging had lower academic achievement in science. Demir and Yıldırım (2022) found that students' sense of belonging to school was not a significant predictor of achievement, while Yıldırım et al. (2021) reported a negative relationship between sense of belonging to school and academic achievement in Turkey in their study based on 2019 TIMSS data. These findings indicate that this relationship, which is mostly described as positive in the international literature, may differ in the Turkish context. The negative relationship observed in the present study is a remarkable finding contrary to the general trend in the literature. Some studies have suggested that the sense of belonging of students with high academic achievement may decrease over time (Pedler, Willis, & Nieuwoudt, 2022; Yıldırım et al., 2021), which may be attributed to students with higher standards being disappointed with the school's climate or social relations. In exam-oriented education systems such as that of Turkey, students' sense of belonging may weaken over time under academic pressure (Erten & Burden, 2014). The findings of this study show both similarities and differences with previous studies, suggesting that the relationship between school belonging and academic achievement is complex in Turkey. Data from the 2022 PISA confirm that students in Turkey have a weaker sense of belonging to school than the OECD average. Approximately 70% of students stated that they "belonged" at school, while 30% felt excluded (MoNE, 2023). In Turkey, students' weekly learning time is close to the OECD average, but durations of up to only 27 hours of learning time per week support academic achievement (MoNE, 2023).

Studies in the literature have demonstrated that valuing science and enjoying science learning have a positive and significant effect on students' levels of science achievement (Martin et al., 2016; Burns, Martin, Kennett, Pearson, & Munro-Smith, 2020; Lay & Rajoo, 2020). Data from the 2019 TIMSS similarly showed that valuing and enjoying science had a strong relationship with students' achievement (Mullis & Martin, 2017). In the present study, a negative correlation was observed between the value that Turkish students attribute to science and their enjoyment of learning science and their TIMSS science achievement in both 2015 and 2019. Several studies using TIMSS 1999, 2007, 2011, 2015, and 2019 data investigated the factors affecting Turkish students' science achievement. In these studies, a negative or insignificant relationship was found between students' attitudes toward science and their science achievement (Ceylan & Berberoğlu, 2007; Sarier, 2020; Yıldırım et al., 2021). In other studies

conducted in Turkey, no significant relationship was found between students' attitudes toward science and their achievement (Altınok, 2005; Külçe, 2011). According to the Ministry of National Education's General Directorate of Measurement, Evaluation, and Examination Services (2024) report, students' attitudes toward science were found to be negatively related to their science achievement in Singapore, Japan, and South Korea. According to 1999 and 2007 TIMSS data, the discrepancy between South Korean students' high achievement in science and their negative attitudes toward this subject could be explained by cultural factors. In addition, international assessments may not fully capture the unique educational and cultural structures of countries (Han & Shim, 2023). In Turkey, this situation may be caused by factors such as students' high perceptions of failure, low self-efficacy, insufficiently effective student-centered activities, and incompatibility between the measurement methods of international tests and classroom learning environments (Ceylan & Berberoğlu, 2007). In the 2015 PISA report, there are detailed comparisons of the differences between Turkey and other OECD countries in terms of students' affective characteristics such as enjoyment of learning science, valuing science, and self-efficacy in science. This points to complex relationships between motivation and enjoyment (MoNE, 2016). Taken together, these findings suggest that despite students' positive affective attitudes toward science learning in Turkey, other factors affecting achievement may differ internationally.

Results from TIMSS 1999 and 2011 showed that students with higher self-confidence generally performed better in science (Martin et al., 2012; Mullis et al., 2000). A study conducted with TIMSS 2019 data in Turkey also reported a positive relationship between confidence in science and science achievement (Yıldırım et al., 2021). According to TIMSS 2019 data, students' science self-confidence had a positive effect on their achievement (Demir & Yıldırım, 2022). A study of Taiwanese high school students found a significant relationship between science achievement and confidence in science; students with high confidence outperformed their peers with low confidence (Chang & Cheng, 2008). Similarly, an analysis of TIMSS 2011 results of fourth-grade students in South Korea revealed that confidence in science was a significant predictor of science achievement (House & Telese, 2017). A study of tenth-grade chemistry students in the United Kingdom found that confidence-based learning assessments significantly increased students' science confidence, but their achievement levels remained similar (Charnley, 2021). These findings highlight the importance of increasing students' confidence in science to improve academic outcomes. Consistent with the literature, the present study found that as confidence in science increased, so did science achievement.

In countries such as Singapore and South Korea, enjoyment of science is positively correlated with high achievement. In these countries, enjoyment is accompanied by the ability to cope with cognitive challenges and continue learning with interest (Martin et al., 2020).

In countries such as Japan and Taiwan, valuing science is supported by both motivational and behavioral components (OECD, 2020). While success declines as homework frequency increases in Turkey, high-quality homework practices contribute positively to success in Singapore (Mullis et al., 2020). This may be related to the structure and quality of homework and the burden it places on students. On the other hand, in high-achieving countries, homework is more focused on problem solving, research, and application. In Singapore, homework is designed to develop students' higher-order thinking skills, which is a factor that supports success (Mullis et al., 2020).

In countries such as Georgia and Kazakhstan, the effect of a sense of belonging on success has been found to be neutral or negative. In contrast, in some other countries such as Finland, a positive relationship between belonging and academic success has been identified (OECD, 2020).

Schools should encourage students to plan for higher education through careers advice, mentoring programmes in scientific fields and discussions. Parents should be involved in their children's education. Assignments should help students understand, not just memorise. Teachers should set homework that matches abilities and interests. Schools should create an inclusive, supportive environment where students feel they belong without losing sight of their academic goals. We need to understand why high-achieving students in Turkey feel disconnected. Programmes to address this could include counselling and activities that make students proud of their schools. Schools should encourage confidence in science through activities that build skills, e.g., feedback. Encouraging students to solve problems with each other can also help them feel more confident and understand more.

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