Determining the Predictors of Mathematics Performance in Türkiye: Implications for Low and High Performing Learners from PISA 2022

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Abstract

The aim of this study is to identify the variables predicting low and high mathematics performance among students in the PISA 2022 Turkey sample and to investigate how these variables operate within each group. The research was conducted using a correlational research design. The study examined the effects of students' perceptions of school, social and emotional skills, academic environment and emotions, and family and socioeconomic status on different performance levels. Multiple regression analysis was conducted to examine the effects of the variables on different performance levels. The study used data from 5166 students in the open-access Turkey sample. Based on the regression analysis of the variables, the study found that the variables predicting achievement levels differed between those with low and high mathematics performance. The classroom discipline, curiosity, and feeling safe predicted the success of high-performing students, while curiosity, empathy, patience, and socioeconomic status predicted the success of low-performing students.

Keywords: Achievement gaps, affective characteristics, Chow test, mathematics performance, PISA 2022, value expectanc.

Türkiye'de Matematik Performansının Yordayıcılarının Belirlenmesi: PISA 2022'nin Düşük ve Yüksek Performans Gösteren Öğrenciler İçin Etkileri

Öz

Bu çalışmanın amacı, PISA 2022 Türkiye örneklemindeki öğrenciler arasında düşük ve yüksek matematik performansını öngören değişkenleri belirlemek ve bu değişkenlerin her grup içinde nasıl işlediğini araştırmaktır. Araştırma, değişkenler arası ilişkiler incelendiği için nicel araştırma yaklaşımlarından korelasyonel araştırma deseninde gerçekleştirilmiştir. Çalışmada,

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öğrencilerin okul, sosyal ve duygusal beceriler, akademik ortam ve duygular ile aile ve sosyoekonomik statü algılarının farklı performans düzeylerine olan etkileri incelenmiştir. Ele alınan değişkenlerin farklı performans düzeylerine olan etkilerin incelenmesi için çoklu regresyon analizi yapılmıştır. Araştırmada açık erişimli PISA 2022 Türkiye örnekleminde yer alan 5166 öğrenciye ait veriler kullanılmıştır. Çalışmada, ele alınan değişkenlerin regresyon analizine dayanarak, düşük ve yüksek matematik performans gösterenler arasında başarı seviyelerini öngören değişkenlerin farklılık gösterdiği bulunmuştur. Dersin disiplin ortamı, merak ve kendini güvende hissetme gibi faktörler yüksek performans gösteren öğrencilerin başarısını önemli ölçüde öngörürken, merak, empati, sabır ve sosyoekonomik statü gibi özellikler de düşük performans gösteren öğrencilerin başarısını önemli ölçüde öngörmüştür.

Anahtar Kelimeler: *Başarı farkları, Chow testi, değer beklentisi, duyuşsal özellikler, matematik performansı, PISA 2022.*

Introduction

Mathematics is a prominent discipline in all educational systems and is considered a basic requirement for many professions. It is essential not only for solving problems and realising technical applications, but also for developing skills such as logical thinking, problem-solving, and critical thinking, which are necessary for academic competence (Gordon, 2024). While deficiencies in mathematics education, prevent individuals from reaching their full potential (Zacharopoulos et al., 2021), achieving a high-quality mathematics education empowers individuals, reduces educational inequalities, and facilitates learners' access to social opportunities (Golding, 2018). For this reason, all countries have been working to improve the quality of mathematics education and are increasing their efforts in this process.

Teachers have difficulty fully realising the mathematics teaching process because mathematics subjects are closely related to other disciplines, widely used in daily life, and the teaching process is often perceived as abstract (Coles & Helliwell, 2023; English, 2015). These difficulties in the mathematics teaching process should be addressed to achieve social education goals, as mathematics has a wide range of applications in life, is related to various disciplines, and the technological infrastructure is based on mathematics (Kelley & Knowles, 2016; Watanabe, 2023). From a global perspective, multiple factors, including socioeconomic status (SES), educational background, and social and affective aspects, influence individuals' mathematics performance. SES-related differences in math ability emerge before school entry and tend to widen over time; these differences are mediated by inhibitory control and verbal ability rather than home activities or working memory (Else-Quest et al., 2010).

In PISA 2022, Türkiye ranked 39th out of 81 countries with an average math score of 453, significantly behind many of its international peers (Sincer et al., 2024). SES-related achievement gaps in mathematics are among the largest in Türkiye compared

to European Union countries; among similarly situated countries, only Hungary shows similarly significant gaps between low- and high-SES learners (Yetkiner Özel et al., 2013). In Türkiye, access to qualified teachers and schools, and therefore to quality mathematics education, is directly related to SES. As a result, SES play a crucial role in the performance gap between low and high achievers (Yetkiner, 2010).

Numerous studies aim to identify the emotional and socioeconomic factors linked to learners' performance across various subjects. However, conducting such research with large datasets, such as those from the PISA exam among both low- and high-achieving learners, would yield more comprehensive results. Additionally, the existing literature has limited studies examining both emotional and socioeconomic factors. Including these variables can increase the amount of variance explained and better account for differences in achievement among learners. Studies on different performance levels have shown that the variables predicting achievement and their effects vary (Elle-Quest, 2010; Yetkiner, 2010; Yetkiner Özel et al., 2013; Breda et al., 2018; James-Brabham et al., 2021; Karakuş et al., 2023).

Türkiye actively participates in the Programme for International Student Assessment (PISA), which the OECD conducts every three years to evaluate the mathematics, science, and reading skills of 15-year-old students. Participating in PISA allows Türkiye to compare its education system with global standards and track its progress over time (Sincer et al., 2024). PISA offers a comprehensive, data-driven measure of student achievement and education quality. Comparative studies using PISA data have shown that Türkiye's structured curriculum and emphasis on hands-on learning lead to higher science literacy scores compared to those of some other countries. PISA results enable international comparisons, helping Türkiye learn from high-performing countries and adopt successful practices, such as ongoing professional development for teachers and integrating techno-pedagogical skills (Ataman & Orhan, 2023; Erümit & Keleş, 2022).

Social and Emotional Dimensions of Achievement Differences

Differences in learners' performance are influenced by SES, and psychological variables like motivation, belonging, and anxiety, which affect how performance is reflected achievement. Social-Cognitive Theory emphasises how threats to implicit beliefs about social identity, sense of belonging, and intelligence can undermine motivation and performance, especially for learners from non-routine backgrounds (Binning & Browman, 2020; Spitzer & Aronson, 2015). Learners' beliefs about their abilities and the value they place on academic tasks can directly or indirectly predict motivation and achievement outcomes (Harackiewicz et al., 2016; Cury et al., 2006).

Social-Cognitive Theory emphasises the impact of social relations on learners' cognitive processes, arguing that mental processes cannot be fully understood without considering their social context. According to this theory, learners' cognitive processes are influenced by social phenomena and are in a dynamic interrelationship

with one another. Individuals' self-efficacy, perceived efficacy, goal orientations, and self-regulation all influence learners' choices, perseverance, and persistence in academic settings (Dai et al., 1998; Schunk, 1999; Schunk & Di Benedetto, 2020). Interventions that enhance learners' social skills improve their cognitive processes and academic performance. Repo et al. (2025) examined students' "latent profiles" in their study using PISA 2022 data. The findings of the study determined how student profiles differed based on factors such as belonging and bullying. Furthermore, this study provides indirect evidence of the structural validity of the scales used in PISA 2022. Li et al. (2025) conducted a study on the reliability and reliability levels of the scales used for the "Being Bullied" and "Sense of Belonging" variables, providing evidence of their validity and reliability. Furthermore, the results from this study emphasized similar results in the PISA technical report. Many studies in the literature reveal that students' psychological characteristics and SES variables affect their performance levels.

Ecological Systems and Achievement Differences

Ecological Systems Theory suggests that a child's development is influenced by multiple, interacting environmental systems (Bronfenbrenner & Morris, 2006), extending from immediate settings like family and school (microsystem) to broader societal factors like culture and politics (macrosystem) and the passage of time (chronosystem) (Crawford, 2020; Hertler et al., 2018). The interactions between these systems can have various effects, including an impact on learners' academic results. Ecological Systems Theory helps explain some of the ways poverty and related issues adversely affect educational outcomes, pointing to systemic changes that can lead to improved educational success (Nation et al., 2020).

Microsystems are systems with the narrowest scope, including direct interaction areas such as family and school, which play a crucial role in shaping learners' mathematics learning Microsystems are narrow-scope systems like family and school that influence learners' math learning and attitudes. Positive, supportive environments can boost achievement, but poor or resource-limited settings may lead to poor performance. environments in these areas can boost mathematics achievement, while environments with unfavourable conditions or limited resources can lead to poor performance (Lubis et al., 2024; Zaatari & Maalouf, 2022). Interactions between different microsystems, such as family and school, are essential for either reducing or widening performance gaps. The connections between these microsystems, forming the mesosystem, are a key factor in enhancing learner achievement (Stanley & Kuo, 2022). This theory's logic applies to organisational development, offering a framework to understand how developmental processes (like teaching and learning) and outcomes (such as student achievement) vary based on the school and its surrounding ecological systems. Most methods for studying school educational outcomes rely on this model, using linear algorithms that simplify systems into isolated parts. These models assume inputs lead to predictable outcomes. (Johnson,

2018). Ecosystem elements, such as parents' work environments and the resources that society provides to students, may also be essential to student achievement. From a general perspective, it is well understood that elements of the macrosystem, including societal values, cultural norms, educational policy expectations, and resource allocation, influence educational inequality and achievement outcomes (Chan et al., 2016; Hertler et al., 2018). Lastly, changes over time, such as educational reforms or technological developments—which can be referred to as the chronosystem—can alter the appearance of differences in mathematics learning and performance (Navarro & Tutge, 2022; Zaatari & Maaluf, 2022).

Schools have distinct climatic structures not only with their physical structures but also through the institutional frameworks they establish. School climate is associated with increased academic success, students' well-being, violence prevention, and teachers' comfort at school, and is effective in the multifaceted development of students in a way that benefits society (Cohen et al., 2009; Thapa et al., 2013). An examination of the research literature reveals that school and classroom climates that support students can help mitigate the adverse effects of low socioeconomic status on academic outcomes and reduce achievement gaps . Although a favourable school climate is associated with better educational outcomes, most studies do not reveal clear causal relationships or directional effects. Further research is needed to understand the mechanisms by which school climate influences academic achievement and to identify effective interventions (Berkowitz et al., 2017). When socioeconomic status is taken into account, the relationship between teachers and their students and variables related to the classroom disciplinary environment have an impact on the performance levels of students (Liu et al., 2024).

Integrating these frameworks into a socio-ecological developmental systems approach can provide a more comprehensive understanding of how the interactions of social structures, institutional factors and individual-level processes shape developmental processes in humans. Identifying the variables that reveal differences in learners' academic achievement is considered necessary to identify the system deficiencies that lead to these achievement gaps, while also enabling the reorganisation of inter-systemic relationships. In this respect, the variables in this area were included in the study to examine the effects of environmental variables on different levels of mathematics performance.

Value Expectancy and Achievement Gaps

Expectancy- Value Theory, proposes that learners' achievement-related choices and performance are primarily determined by their beliefs about how well they will perform a task (expectancy) and how much they value the task (value). The theory has evolved to include multiple dimensions of value (gain, intrinsic, benefit, and cost) and emphasises the role of social, cultural, and situational factors in shaping these beliefs (Eccles & Wigfield, 2020; 2024). Research suggests that socioeconomic status predicts academic achievement both directly and indirectly through expectancy and

value beliefs. Learners from higher SES backgrounds tend to have higher motivation, which mediates the relationship between SES and achievement, contributing to achievement gaps (Yeung et al., 2022).

Learners' expectations and value beliefs are key to reading achievement. Past studies have focused mostly on these at the learner level. Little research has examined how school-level expectancy-value beliefs—those of classmates—relate to learners' reading success. It's important to consider both levels and cultural differences.(French et al., 2023). The interactions between expectation and value in relation to success are more evident in adolescents than in young children. As learners mature, the synergy between believing in their abilities and valuing the task becomes more critical for success (Seo et al., 2024). The learner's goals, expectations, values, emotions, and needs constitute the variables that affect motivation before learning. In addition, teacher behaviours, the quality of course materials, peer interactions, the environment, and the learner's effort, skill acquisition, and knowledge structuring also contribute to motivation, which affects the learning process (Schunk, 1999). After the process in which these variables are functionally controlled, the learner who expects to achieve a good result believes that they are making progress, will continue to learn using specific strategies, and thus begins to developesult believes that they are making progress, will continue to learn using specific strategies, and thus begins to develop positive thoughts, perspectives, and attitudes towards the learning process and environment. A democratic atmosphere in which learners feel comfortable contributes to motivation. A collaborative learning environment that encourages motivation, reduces tension in practices, and fosters a high sense of self-efficacy. These effects on learners also affect the level of learners' sense of security and their trust in school. The behaviours and expectations of socialisers, such as family, friends, and teachers, directly affect learners' goals, task-specific self-concepts, and their interpretation of past experiences.

The effects of variables on the academic achievement of learners at different levels have been explored in numerous studies. These studies include examining how high and low achievement levels influence confidence in school (Mohammadpour & Shekarchizadeh, 2013), the impact of field-specific affective variables (Çoban & Kamış, 2019; Yılmaz, 2020), and motivation levels (Prast et al., 2018). Yılmaz (2020) examined variables predicting high achievement at learner and class levels using PISA data. Results showed that the influential variables differ by learner and school levels. Additionally, Mohammadpour and Shekarchizadeh (2013) studied changes in Iranian eighth-grade learners' high and low achievement levels in relation to school and learner levels. Their results showed that the school had a significant effect on maths achievement, and the level of trust was related to achievement. Çoban and Kamış (2019) studied TIMSS data, finding that emotional and socioeconomic variables predict achievement levels. Test anxiety and environmental optimism were higher in low-achieving learners, while achievement motivation, collaboration enjoyment, environmental awareness, self-efficacy, epistemological beliefs, ESCS, and ICT

resources were higher in high-achieving learners. Biber (2012) examined the effects of affective characteristics on performance in his study. His research determined that improving affective characteristics contributes positively to performance. The results of the current study can be compared with the changes in the performance impact of affective, social, and family characteristics across different groups. This allows us to identify the variables affecting student performance across different groups and their potential impact. Thus, the results of the current study can point to interventions that can be implemented to improve students' current performance levels.

This study examined the effects on students' academic skill levels through Social Cognitive Theory, Ecological Systems Theory, and Expectancy–Value Theory. However, when the PISA variables examined in the study were examined in literature, it was deemed appropriate to categorize them into *"Perceptions about the School, Social and Emotional Skills, Academic Environment and Emotions, and Family and Socioeconomic Status"*. This grouping of variables could be explained by their reflection of their respective conceptual groupings. For example, the variables discussed may have reflected school-related processes, a tendency toward academic skills, emotional influences, or socioeconomic status and family characteristics, leading to this grouping. In this study, the theoretical theories underlying the variables on students' skill levels were considered, based on the groupings of relevant variables in the literature, and the areas where their potential effects are reflected.

The PISA assessment provides information on variables that may make a difference in mathematics achievement by taking into account many different variables in addition to predictors, which are widely mentioned in the current literature. The information provided by this internationally comparable, valid, and reliable data set is important in identifying predictor variables between low- and high-achieving learners, determining the effects of educational inequalities, and identifying predictors that have not been studied in the field. The current study, unlike studies conducted on students' cognitive skills based on various affective variables, was conducted using comprehensive variables based on a theoretical framework. It differs from studies in the literature in that the variables were examined simultaneously from academic, social, family, and school perspectives. Because it aims to identify the potential effects of students' different affective variables, it is expected to provide comprehensive results for practitioners. Specifically, by determining the effects of family, social, academic, and school variables, inferences can be drawn that will contribute to students' performance. Thus, necessary adjustments and practices can be implemented to improve students' academic performance. Therefore, this study aims to identify the variables that predict the achievement of low-performing and high-performing learners. The data from the PISA 2022 application, which was implemented during the study and whose data were made publicly available, were

used. The research questions developed within the framework of this general purpose are as follows;

a. What are the variables predicting the achievement levels of learners with low mathematics performance?

b. What are the variables that predict the achievement levels of learners with high math performance?

c. Do the regression coefficients differ significantly in examining the achievement levels of learners with low math performance and high math performance?

Methodology

This study was conducted as correlational research. Within its scope, data from low and high-achieving learners were analysed, along with how the two established models performed within these groups (Comiskey et al., 2016; Miksza & Elpus, 2018).

Process

The study uses data from 15-year-old learners in the PISA 2022 Türkiye assessment. Learners complete questionnaires that cover their characteristics, opportunities, and socio-emotional aspects. In Türkiye, 7250 learners from 186 schools participated, with 5,166 completing all scales and forming the study group. Of these, 51.3% were boys and 48.7% girls. Data were collected nationwide through a stratified sampling approach. The questionnaires cover opportunities, demographics, emotions, instructional methods, and perspectives on topics like the pandemic and technology (Yüksel, 2024). Additionally, to assess learners' literacy levels in Reading, Science, Mathematics, and Financial Literacy, data on these levels are published on the official OECD website following the assessment. The data used in this study were downloaded from the OECD official website. The codes and descriptions of the variables in the learner questionnaire are provided in Table 1. To enhance data interpretability, the variables were grouped into four factors. Because the study planned to examine the effects of students' value expectations, ecological systems, and social and affective characteristics on performance levels, it was decided to examine variables theoretically related to these characteristics. Studies in the literature and PISA reports were examined to determine the variables associated with these concepts.

Table 1.
Variables, Codes and Explanations

Factor	Name	Label	Explanation

Perceptions of the School	FEELSAFE (ST265)	Feeling Safe	It is a 4-item Likert-type scale that evaluates how safe learners feel at school. High values obtained from the scale indicate that learners have a high level of feeling safe at school.
	BELONG (ST034)	School belonging	Learners' sense of belonging to school is measured using six items. PISA defines school belonging as the degree to which learners feel that they belong to the school.
	RELATST (ST267)	The quality of teacher learner relationship	It is measured by an 8-item scale assessing learners' relationship with the teachers.
	BULLIED (ST038)	Being Bullied	It includes 9 items related to the frequency of bullying. Each of the five items in this scale has two response options.
	SCHRISK (ST266)	School Risk Perception	It was measured with 5 binary items measuring safety risks experienced in the last 4 weeks.
Social and Emotional Skills	ASSERAGR (ST305)	Determination	The degree to which learners agree with statements about a set of behaviors indicative of these social and emotional skills. Each is assessed on a 10-item, 5-point Likert-type scale
	EMPATAGR (ST311)	Empathy	
	COOPAGR (ST343)	Cooperation	
	CURIOAGR (ST301)	Curiosity	
	EMOCOAGR (ST313)	Emotional Control	

	PERSEVAGR (ST307)	Perseverance	
	STRESAGR (ST345)	Stress resilience	
Academic Environment and Emotions	TEACHSUP (ST270)	Mathematics Teacher Support	Frequency of teacher support in mathematics lessons, 4-item scale.
	ANXMAT (ST292)	Mathematics Anxiety	Anxiety level about mathematics, 6-item scale.
	DISCLIM (ST273)	Disciplinary environment in mathematics	Perception of classroom discipline in mathematics lessons was assessed with 7 items.
Family and Socioeconomic Status	FAMSUP (ST300)	Family Support	A 10-item frequency-based scale measuring family support for the learner.
	ESCS (ESCS)	Socio-economic and Cultural Index	Composite index value based on parental education, occupational status and educational resources at home

The OECD (2024) published a report detailing the PISA 2022 measurement processes, including survey development, quality control, translation, and data collection. The report also provides detailed explanations of the data collection and scale development processes. This can be used as evidence for the validity of the measurement tools used in the study. Ouyang et al. (2025) conducted an analysis of PISA 2022 data and focused on measurement inequality, which is an important methodological study in terms of validity, examining whether scales measure the same construct for students in different countries. This can be presented as evidence of the construct validity of the measurement invariance of the scales used in PISA 2022 across different countries. Similarly, Repo et al. (2025) provided indirect evidence of the structural validity of the scales used in practice in their study on PISA 2022 data. Presenting some sample items from the scales applied in the PISA 2022 application may provide a better explanation of these structures. Sense of belonging; "*I feel like I belong at this school.*", "*I feel lonely at school.*", being bullied example

items; "*being left out on purpose*", "*other students made fun of me*", "*being threatened by other students*", emotional control example item; "*I find it difficult to control my feelings when I'm upset.*"; perseverance example item; "*When I'm working on a difficult task, I keep going even if it's hard.*"; curiosity exammple item; "*I like to find out new things, even if they are difficult to understand.*"; family support example items; "*My family helps me with school work*", "*My parents talk with me about school*" It may include expressions such as.

An examination of the items reveals that the scales contain statements that reflect the structure of the variables under consideration. The items in the scales used in the PISA application are first developed through in-depth studies at the OECD headquarters and then sent to national centers for further review. Following these reviews, the implementation phase begins. Both OECD reports (OECD, 2023a; 2024) and studies in the literatüre (Li et al., 2025; Repo et al., 2025) provide sufficient evidence of the validity and reliability of the measurement instruments. Similarly, OECD (2023a) presents findings from its "Well-being / School Life" context surveys (school safety, belonging, bullying). This report specifically examines statistical relationships and compares scales such as "Feeling Safe," "School Security Risks," "Being Bullied," and "Sense of Belonging." These comparisons conclude that the scales have high reliability and provide valid information about students' school lives.

Data Analysis

Because the study examined the effects of multiple variables, the Chow test was conducted to assess the necessity of conducting multiple regression and regression analysis across different groups. To conduct multiple regression analysis, the assumptions for the analysis were first examined. Once these assumptions were met, the analyses were conducted. The data obtained within the scope of the study were first cleaned of missing data in the theoretical model. Then, the extreme values were examined, and data containing extreme values, as determined by the Mahalanobis distances, were excluded from the study. Next, it was assessed whether the data met the assumptions of univariate and multivariate normality. Skewness and kurtosis coefficients were analysed to examine the univariate normality of the data. It was found that the skewness and kurtosis values were within the desired ranges (-2 to +2) (Table 2). For the multivariate normality assumptions, correlation analysis, tolerance values, and variance inflation factors (VIF) were used. After editing the learner survey data file to remove parts containing missing data for the study variables, the analysis processes were carried out. R and JAMOVI programs were used to analyse the data.bırakınız.

Results

The 17 variables in the PISA 2022 dataset were categorised under five distinct psycho-emotional factors. Descriptive statistics for these variables are shown in Table 2.

Table 2.
Descriptive Statistics of The Variables in The Study

Factor	Variable	Min.	Max.	Mean	S.Dev.	Skew.	Curt.	α
Perceptions of the School	Sense of Belonging	-2.88	2.45	-.32	.79	.47	1.17	.87
	Quality of Learner-Teacher Communication	-3.56	3.61	-.22	.94	.39	.55	.89
	Being Bullied	-1.22	2.88	-.23	.99	.47	-1.01	.82
	Feeling Safe	-2.78	1.12	-.46	.96	.32	-.65	,91
	School Safety Risks	-.63	3.64	.28	1.11	.94	-.04	,88
Social and Emotional Skills	Perseverance	-3.00	3.30	.06	.85	.81	1.28	.94
	Curiosity	-2.93	3.68	.27	.97	.84	1.14	.97
	Cooperation	-2.92	3.43	-.01	.81	.76	1.11	.82
	Empathy	-3.00	3.57	.07	.91	.86	1.49	.85
	Determination	-2.61	3.54	.17	.74	.52	1.27	.85
	Resilience to Stress	-3.23	2.92	-.02	.75	-.51	1.62	.93
	Emotional Control	-3.00	2.78	-.11	.74	-.26	1.27	.83
	Discipline Environment in	-2.42	2.03	-.00	.84	.10	.58	.95

Academic Environment and Emotions	Mathematics Teaching							
	Mathematics Teacher Support	-2.90	1.55	-.26	1.03	.01	.03	.91
	Mathematics Anxiety	-2.39	2.63	.60	1.09	-.01	.35	.88
Family and Socioeconomic Status	Family Support	-2.99	1.95	-.18	1.01	.12	.08	.87
	Socio-economic and Cultural Index	-5.02	1.96	-1.18	1.16	.21	-.70	-

The skewness and kurtosis values of the variables examined in the research indicate that the data fall within the reference range (-2, +2), suggesting an acceptable normal distribution (Tabacknick & Fidell, 2013). When the reliability values of the scales used in the study calculated according to the sample were examined, it was determined that these values were at an acceptable and high reliability level. VIF and tolerance values for the second assumption of multiple regression are provided in Table 3. The tolerance and VIF values showed no multicollinearity problem among the variables analyzed in the research.

Table 3.
VIF and Tolerance Values of The Variables in The Study

Factor	Variable	Tolerance	VIF
Perceptions of the School	Sense of Belonging	.811	1.233
	Quality of Learner-Teacher Communication	.753	1.327

	Being Bullied	.794	1.260
	Feeling Safe	.855	1.170
	School Safety Risks	.802	1.247
Social and Emotional Skills	Perseverance	.775	1.291
	Curiosity	.758	1.320
	Cooperation	.746	1.341
	Empathy	.741	1.349
	Determination	.795	1.258
	Resilience to Stress	.764	1.309
	Emotional Control	.793	1.261
Academic Environment and Emotions	Discipline Environment in Mathematics Teaching	.838	1.193
	Mathematics Teacher Support	.888	1.126
	Mathematics Anxiety	.888	1.126
Family and Socioeconomic Status	Family Support	.910	1.098
	Socio-economic and Cultural Index	.951	1.051

In the study, missing data were first removed from the variables covered in the study. Then, to separate students into low- and high-performance groups, their math performance levels were determined. Students were then ranked according to their performance levels, and the data set was split down the middle. This resulted in two groups: low and high performers, and analyses were conducted on these groups. To

verify the assumptions of the analysis process, the learner group was sorted from high-performing to low-performing individuals based on their mathematics performance and divided into two groups according to the number of individuals in each. The data set was then split into separate datasets for high and low performers, and analyses were conducted for each group. In this study, to determine the variables predicting achievement levels based on group membership, multiple regression analysis was used because there was more than one independent variable.

Findings Regarding the Variables Predicting the Achievement Level of Learners with Low Mathematics Performance

Multiple regression analysis was performed to identify the variables that predict learners' mathematics achievement levels among those with low performance. The results of the regression analysis, including these variables, are presented in Table 4. The variables that significantly predicted mathematics performance for learners with low achievement in the PISA 2022 Türkiye sample included feeling safe, curiosity, empathy, assertiveness, disciplinary climate in Maths, teacher support in Maths, and ESCS. Furthermore, it was found that the variables examined in the study accounted for 7% of the variance in learners' mathematics achievement. Although this explained variance may seem small, considering that more than 200 variables are included in large-scale assessments such as PISA, TIMSS, and PIAAC, even variance changes of 1% or 2% can be regarded as meaningful (Güven & Sezer, 2000; Yüksel, 2024).

Table 4.

Variables Predicting the Achievement Level of Learners with Low Mathematics Performance

Factor		Standartised Coefficents		Unstandartised Coefficients		
	Variable	B	S. Error	β	t	p
	(Constant)	398,443	1,718		231,875	,000 *
	Sense of Belonging	1,689	1,120	,031	15,508	,132

Perceptions about the School	Quality of Learner-Teacher Communication	-,803	,985	-,018	-,815	,415
	Being Bullied	-1,717	,882	-,041	-1,946	,052
	Feeling Safe	-3,800	,911	-,085	-4,171	,000*
	School Security Risks	-,738	,787	-,020	-,937	,349
Social and Emotional Skills	Perseverance	1,078	1,066	,022	1,011	,312
	Curiosity	4,971	1,014	,110	4,901	,000*
	Cooperation	-1,468	1,152	-,029	1,274	,203
	Empathy	4,056	1,006	,090	4,034	,000*
	Determination	4,129	1,261	,069	3,274	,001*
	Resilience to Stress	-,231	1,263	-,004	-,183	,855
	Emotional Control	,304	1,224	,005	,248	,804
Academic Environment and Emotions	Discipline Environment in Mathematics Teaching	2,154	1,029	,043	2,093	,036*

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	Mathematics Teacher Support	-2,539	,863	-,063	-2,943	,003 *
	Mathematics Anxiety	-,391	,762	-,010	-,512	,608
Family and Socioeconomic Status	Family Support	1,412	,770	,037	1,833	,067
	Socio-economic and Cultural Index (ESCS)	4,744	,802	,114	5,915	,000 *

*p<.05

Findings Regarding the Variables Predicting the Achievement Level of Learners with High Mathematics Performance

The regression analysis findings in Table 5 show the variables that predict the mathematics achievement levels of learners with high performance. The results indicated that bullying, feeling safe, school safety risks, curiosity, cooperation, disciplinary climate in mathematics, mathematics anxiety, family support, and socioeconomic and cultural index variables explained approximately 15% of the variance in the achievement level of learners with high mathematics performance in the PISA Türkiye sample. It was determined that the variables predicting the achievement levels of learners with low achievement and those with high achievement were similar. However, when considering the variance explained, it was found that these variables accounted for a greater proportion of variance in high-achievement learners. This suggests that these variables have a more substantial influence on the achievement level of high achievers.

Table 5.
Variables Predicting the Achievement Level of Learners with High Mathematics Performance

Factor	Variable	Standartised Coefficents		Unstandartised Coefficients	t	p
		B	**S. Err**	**β**	**t**	**p**

	(Constant)	549,003	1,589		343,599	,000*
Perceptions about the School	Sense of Belonging	-,350	1,426	-,005	-,246	,806
	Quality of Learner-Teacher Communication	-,686	1,199	-,012	-,572	,567
	Being Bullied	2,759	1,157	,049	2,384	,017*
	Feeling Safe	4,211	1,114	,076	3,780	,000*
	School Security Risks	4,402	1,040	-,087	-4,234	,000*
Social and Emotional Skills	Perseverance	-1,071	1,328	-,017	-,807	,420
	Curiosity	4,364	1,126	,080	3,874	,000*
	Cooperation	-4,015	1,429	-,059	2,810	,005*
	Empathy Empathy	1,980	1,297	,032	1,526	,127
	Determination	,330	1,450	,005	,228	,820
	Resilience to Stress	-1,427	1,441	-,021	-,990	,322
	Emotional Control	1,196	1,483	,017	,806	,420
	Discipline Environment in	7,367	1,319	,113	5,584	,000*

Academic Environment and Emotions	Mathematics Teaching					
	Mathematics Teacher Support	-,937	1,079	-,018	-,868	,385
	Mathematics Anxiety	-8,097	,991	-,158	-8,166	,000*
Family and Socioeconomic Status	Family Support	-3,987	1,139	-,067	-3,500	,000*
	Socio-economic and Cultural Index	12,109	,858	,263	14,116	,000*

*p<.05

Findings Regarding the Changes in Regression Coefficients of Variables Predicting the Success Level of Learners with Low and High Mathematics Performance

The Chow Test was applied to examine whether the regression analysis conducted for the two groups, determined as low and high mathematical achievement, revealed a difference between the groups and to determine whether a causal relationship could be established in the same way. As a result of the test, it was found that the regression coefficients between the low and high achievement groups were significantly different, $F(18, N-2k) = 478.13$, $p < .001$. This situation shows that the model should be evaluated separately for both groups.

Discussion

When variables predicting the success levels of students with low mathematics performance were examined, the perceived school-related variable, "feeling safe at school," was found to be significantly and inversely correlated. The other variables in this section were found to be statistically insignificant. Among the variables involving social and emotional skills, the variables of curiosity, empathy, and determination were found to be statistically significant and had approximately similar effects according to the regression coefficients. The other variables in this section were statistically insignificant. Among the variables in the academic environment and emotions section, the effect of the disciplinary environment was found to be positive and significant, while the effect of the mathematics teacher's support was found to be

significant but inversely influential. Math anxiety was found to be statistically insignificant. Among the variables related to family and socioeconomic status, the effect of family support was found to be statistically insignificant, but the effect of the socioeconomic status index was found to be significant and high according to the regression coefficient. When variables predicting the success levels of students with high mathematics performance were examined, it was determined that the perceived school variables of feeling safe at school, the level of bullying, and the level of school security were significantly and positively correlated. The other variables in this section were not statistically significant. Among the variables involving social and emotional skills, the curiosity variable was found to have a significant and positive effect, while the cooperation variable was found to have a significant but inverse effect. The other variables in this section were statistically insignificant. Among the variables in the academic environment and emotions section, the disciplinary environment was found to have a positive and significant effect, while the math anxiety variable was found to have a significant but inverse effect. The math teacher's support variable was found to be statistically insignificant. Among the variables related to family and socioeconomic status, the effect of family support was found to be statistically significant but inversely correlated, and the effect of the socioeconomic level index was found to be significant and high according to the regression coefficient.

Many different variables predict learners' success in mathematics. This study aimed to examine the effects of 17 different variables measured in the PISA 2022 application under 5 main factors on low and high-achieving learners. Such studies have been conducted in Türkiye with different scales and sample groups (Anıl, 2009; Ceylan & Berberoglu, 2007; Demir, 2016; Çoban & Kamış, 2019). According to the results of the current research, the variables that predict the success levels of learners for both low- and high-achieving groups are the Socioeconomic and Cultural Index (ESCS), the disciplinary environment of the classroom, curiosity, and feeling safe at school. Apart from these, the variables that predict the success of low and high-performing learners differ (Rusdi, 2018). According to the results obtained from the PISA 2022 application in the report published by OECD (2023b), it was determined that there is a positive relationship between the variables of "curiosity", "persistence", "emotional control" and "stress resistance" and mathematics performance.

It is well established that socioeconomic status has a significant impact on learners' success levels (Anıl, 2009; Korkmaz & Şahin, 2013; Demir, 2016). In a similar context to this study, Demir (2016) stated in his research on PISA results that the ESCS has a significant effect on learners' mathematics achievement. Similar results are also reported in publications issued after the PISA Assessment (OECD, 2010; 2013; 2017; 2019).

Learners' trust levels in school are related to their sense of safety in the school environment. Learners' trust levels in school are affected by different affective and

cognitive variables (Karal, 2011). School safety is influenced by various factors, including exposure to bullying, witnessing violence, and the school climate (Bradshaw et al., 2021; Morrison et al., 1994). Learner success is related to this variable in studies conducted on the level of trust in schools among learners (Coleman, 2011). In his research on the level of trust among high school learners, Romero (2015) found a significant relationship between learner trust levels, types of behaviours, and success levels. The current study also reached a similar conclusion as the variable of trust in school is effective in influencing the success levels of learners. ACER reports findings from its study on PISA 2022 results: "high curiosity," "strong student-teacher relationships (sense of belonging, teacher support)," "low bullying (being bullied)," "high stress resistance," and "perseverance." While this isn't a profile analysis that defines "high achievers vs. low achievers," it does indicate "significant differences between performance and these social-emotional variables".

Curiosity is one of the key variables that affect the success levels of learners, regardless of their mathematics performance levels. Research has shown that as learners' curiosity levels increase, their success rates also rise. A high level of curiosity is associated with adequate mathematics achievement levels among learners in various studies conducted on learners with high achievement levels (Federici & Skaalvik, 2014; De Bortoli et al., 2024). The OECD (2023b) published a report reporting a positive relationship between social-emotional skills such as curiosity, persistence, and emotional control and mathematics performance. This presents a relationship at the regression/correlation level rather than across high and low-achieving groups; therefore, it is not a descriptive study of directly grouped "high vs. low" achievement profiles, but rather provides strong empirical evidence for the relationship between the variables of interest and performance.

According to the research results, learners' family support and math anxiety levels were not significant predictors for low-performing learners, but they became substantial predictors for high-performing learners. This can be interpreted as learners' different levels of math performance and the varying significance of their family support and anxiety regarding math lessons. Additionally, the teacher-learner relationship, controlling emotions, coping with stress, and patience did not have a significant effect on predicting math achievement for either group. The OECD (2024) report found a positive correlation between teacher support and math performance, as well as a correlation between increased teacher support and decreased math anxiety. If students are high achievers, the support they receive from their teachers appears to both increase their performance and reduce their anxiety. PISA data shows that the learner-teacher relationship has a positive impact on learners' learning goals and achievements (Yüksel, 2025). Similarly, Gürz et al., (2024) found that school belonging and the teacher-learner relationship positively influenced academic achievement in their study on the effects of school psychology on learners' academic success, which contrasts with the findings of this study.

In this study, learners were divided into two different groups based on their achievement. The goal was to identify the variables that best explain the differences in achievement among learners. Low- and high-achieving learners may not be sufficiently distinguished by these variables. Consequently, learners with different achievement levels could be similar in these aspects. Another reason for the discrepancy between this study and previous research may be the strength of the relationships found in earlier studies. Variables with weak or moderate links to academic achievement might not effectively differentiate between low and high achievers.

Conclusion and Suggestions

This study aimed to determine the variables affecting the success levels of students with low and high mathematics achievement in the PISA 2022 Turkey sample. The findings showed that variables such as socioeconomic and cultural status (ESCS), classroom discipline environment, curiosity, and feeling safe at school predicted success for both groups. However, it was determined that other variables affecting the success levels of the low- and high-achievement groups differed. While factors such as empathy, perseverance, and teacher support were found to be prominent in low-achieving students, it was concluded that factors like mathematics anxiety, family support, and perception of school safety had a more significant impact on high-achieving students. Additionally, it was found that the variance explained by these variables was higher in the high-achieving group. This indicates that these variables have a more significant impact on high-achieving students.

The research results reveal the significant effect of socioeconomic status on educational achievement. Years of research on students' academic performance have indicated that variables related to socioeconomic status are influential. Based on this study, which presents similar results to previous research, administrators and education policymakers can be encouraged to work towards addressing disparities. Studies can be conducted on creating inclusive educational environments and curricula that include students with diverse characteristics. Based on this study, which highlights the contributions of social and affective variables to cognitive processes in response to both societal and individual needs, the effects of students' emotional states on educational processes can be investigated in greater depth. Activities can be implemented to more effectively utilize the influences of social and affective characteristics in educational processes. In-service training can be provided not only to students but also to teachers, who are the drivers of education. Cognitive development can be supported by developing training programs that address the development of diverse affective characteristics. In this context, the importance of policies to increase access for disadvantaged groups to educational opportunities has been reemphasised. Additionally, interventions aimed at developing emotional and psychosocial skills, such as curiosity, empathy, and perseverance, in the low-achieving group may increase success. Meanwhile, it is recommended that strategies

be designed to reduce mathematics anxiety in the high-achieving group and that learning environments be made more supportive.

It should be noted that the data used in the study were limited to the PISA 2022 Turkey sample and that only 17 variables were analysed. It is recommended that future studies be conducted on different international assessment programs (TIMSS, PIRLS, PIAAC) and different variables. Additionally, variables affecting achievement levels in other disciplines can be examined using similar methods. Such studies can provide valuable insights to reduce educational inequalities and inform the development of more inclusive education policies.

In conclusion, this study has revealed that the variables affecting the achievement levels of students at low and high achievement levels differ and that these differences should be taken into account in educational policies and practices. Customised approaches should be developed for both groups to provide permanent improvements in the education system.

Research and Publication Ethics

In this study, all rules specified in the Scientific Research and Publication Ethics Directive of Higher Education Institutions were followed. None of the actions described under the heading of Actions Contrary to Scientific Research and Publication Ethics in the directive were carried out.

Ethics Committee Permission

Since ready data were used in this study, ethics committee approval is not required. All authors declare that they have no conflicts of interest. No financial support was received from any institution or organisation during the study period.

Author Contributions

Authors contributed equally to this study (Author 1 50%, Author 2 50%).

Conflict of Interest

There is no conflict of interest among the authors in this study.

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Genişletilmiş Özet

Matematik, tüm eğitim sistemlerinde öne çıkan bir disiplin olup birçok meslek için temel bir gereklilik olarak kabul edilir. Sadece sorunların çözülmesi ve teknik uygulamaların gerçekleştirilmesi için değil, aynı zamanda akademik yeterlilik için gerekli olan mantıklı düşünme, sorun çözümü ve eleştirel düşünme gibi yeteneklerin geliştirilmesinde de dikkate değerdir (Gao- Quan, 2006; Gordon, 2024). Bir disiplin olarak ele alınan matematik eğitiminde eksiklikler bireyin tam potansiyelinin ortaya çıkmasını engellemekteyken (Zacharopoulos vd., 2021), yüksek kaliteli bir matematik eğitimine ulaşmak bireyleri güçlendirmekte, eğitim eşitsizliklerini azaltmakta ve öğrencilerin sosyal imkanlara ulaşmasının önünü açmaktadır (Golding, 2018). Bu nedenle tüm ülkeler matematik eğitiminin kalitesini arttırmaya yönelmektedir.

Matematik kimilerine göre sayma işlemi, ölçme işlemi, düşünerek sayma, bir düşünce sanatı, bilimin ortak dili, hesaplama tekniği, bir iletişim aracı, bir disiplin, doğruyu gerçeği görmek şeklinde çeşitli tanımlar yapılsa da üzerinde hem fikir olunduğu bir yanıt henüz bulunamamıştır. Fakat iyi bilinmeli ki, matematik evrensel bir dil olup tüm bilimlerin ortak dili konumundadır. Matematik konularının diğer disiplinler ile ilişkili olması, gündelik hayatta kullanımının geniş bir tutması ve bireylere öğretim sürecinin soyut olarak algılandığı için öğretmenler matematik öğretimi sürecini tam olarak gerçekleştirmekte zorlanmaktadır.

Literatür incelendiğinde, öğrencilerin farklı derslerdeki performansları ile ilişkili duygusal ve sosyoekonomik değişkenlerini belirlemeye çalışan birçok çalışma olduğu açıktır. Ancak, bu çalışmalar başarı dağılımının alt ve üst uçlarında bulunan öğrencilere odaklanmamıştır. Bu çalışmalardan bazıları, bazı değişkenlerin başarıyla zayıf veya orta düzeyde bir ilişkiye sahip olduğunu bulmuştur. Düşük ve yüksek başarı gösteren öğrencilere odaklanmak, öğrenciler arasındaki başarı farkını daha iyi açıklayan değişkenleri belirlemeye yardımcı olabilir. Aşırı başarı gruplarıyla bir çalışma yürütmek, öğrenciler arasındaki başarı farkıyla ilgili faktörleri daha iyi anlamamızı sağlayabilir. Böyle bir yaklaşımla yürütülen araştırmalar, ailelere, okul yöneticilerine ve politikacılara düşük başarı gösteren öğrencilerin performansını iyileştirme stratejileri konusunda rehberlik edebilir. Dahası, hem duygusal hem de sosyoekonomik değişkenleri inceleyen çalışma sayısı sınırlıdır. Öğrenciler arasındaki başarı farkını açıklayabilecek hem duygusal hem de sosyoekonomik değişkenleri dikkate alarak açıklanan varyans miktarı artırılabilir.

Uluslararası karşılaştırılabilir, geçerli ve güvenilir bu veri setinin sağlayacağı bilgiler düşük ve yüksek başarı sağlayan öğrenciler arasındaki yordayıcı değişkenlerin tanımlanması, eğitim eşitsizliklerinin etkilerinin belirlenmesi ve alanda çalışılmayan predictorlerin belirlenmesi açısından önemlidir. Bu nedenle bu çalışma düşük performans gösteren ve yüksek performans gösteren öğrencilerin başarılarını yordayan değişkenlerin belirlenmesini hedeflemektedir.

Araştırma kapsamında öğrencilerin matematik performansları düşük ve yüksek olmak üzere iki gruba ayrılmıştır. Ayrılan bu iki grup için yapılacak olan regresyon analizinin gruplar arasında farklılık oluşturup oluşturmadığının incelenmesi gerekmektedir. Bu kontrolün sağlanması için R programı yardımıyla Chow testi yapılmıştır. Yapılan Chow testi sonucunda düşük ve yüksek başarı grupları arasındaki regresyon katsayılarının anlamlı bir şekilde farklı olduğu bulunmuştur, $F(18, N-2k) = 478.13$, $p < .001$. Bu durum, modelin her iki grup için ayrı ayrı değerlendirilmesi gerektiğini göstermektedir.

PISA Türkiye örneklemi üzerinden düşük matematik performansı gösteren öğrencilerin matematik performanslarını anlamlı şekilde yordayan değişkenlerin; güvende hissetme, merak, empati, sabır, matematik dersindeki disiplin ortamı ve SES olduğu belirlenmiştir. Ayrıca araştırma kapsamında ele alınan değişkenlerin öğrencilerin matematik başarılarının % 7'sini açıkladığı belirlenmiştir. Açıklanan varyans değeri küçük gibi göründe de PISA, TIMSS, PIAAC gibi geniş ölçekli test uygulamalarında 200'den fazla değişken ele alındığı için %1 ya da %2'lik varyans değişimlerinin bile anlamlı olduğu söylenebilir (Güven ve Sezer, 2000; Yüksel, 2024).

Bu çalışma, PISA 2022 Türkiye örnekleminde düşük ve yüksek matematik başarısına sahip öğrencilerin başarı düzeylerini etkileyen değişkenleri belirlemeyi amaçlamıştır. Bulgular, sosyoekonomik ve kültürel durum (ESCS), sınıf disiplin ortamı, merak ve okulda kendini güvende hissetme gibi değişkenlerin her iki grup için de başarıyı yordadığını göstermiştir. Ancak, düşük ve yüksek başarı gruplarının başarı düzeylerini etkileyen diğer değişkenlerin farklılık gösterdiği belirlenmiştir. Empati, azim ve öğretmen desteği gibi faktörlerin düşük başarı gösteren öğrencilerde öne çıktığı görülürken, matematik kaygısı, aile desteği ve okul güvenliği algısı gibi faktörlerin yüksek başarı gösteren öğrenciler üzerinde daha anlamlı bir etkiye sahip olduğu sonucuna varılmıştır. Ayrıca, bu değişkenlerin açıkladığı varyansın yüksek başarı gösteren grupta daha yüksek olduğu bulunmuştur. Bu durum, söz konusu değişkenlerin yüksek başarı gösteren öğrenciler üzerinde daha anlamlı bir etkiye sahip olduğunu göstermektedir.

Araştırma sonuçları, sosyoekonomik durumun eğitim başarısı üzerindeki anlamlı etkisini ortaya koymaktadır. Bu bağlamda, dezavantajlı grupların eğitim fırsatlarına erişimini artırmaya yönelik politikaların önemi yeniden vurgulanmıştır. Ayrıca, düşük başarı gösteren grupta merak, empati ve azim gibi duygusal ve psikososyal becerileri geliştirmeyi amaçlayan müdahaleler başarıyı artırabilir. Bu arada, yüksek başarı gösteren grupta matematik kaygısını azaltmaya yönelik stratejiler geliştirilmesi ve öğrenme ortamlarının daha destekleyici hale getirilmesi önerilmektedir.

Çalışmada kullanılan verilerin PISA 2022 Türkiye örneklemi ile sınırlı olduğu ve yalnızca 17 değişkenin analiz edildiği unutulmamalıdır. Gelecekte farklı uluslararası değerlendirme programları (TIMSS, PIRLS, PIAAC) ve farklı değişkenler üzerinde çalışmalar yapılması önerilmektedir. Ayrıca, diğer disiplinlerdeki başarı düzeylerini etkileyen değişkenler de benzer yöntemler kullanılarak incelenebilir. Bu tür

çalışmalar, eğitim eşitsizliklerini azaltmak ve daha kapsayıcı eğitim politikalarının geliştirilmesine katkı sağlamak için değerli bilgiler sağlayabilir.

Sonuç olarak, bu çalışma, düşük ve yüksek başarı düzeyindeki öğrencilerin başarı düzeylerini etkileyen değişkenlerin farklılık gösterdiğini ve bu farklılıkların eğitim politikaları ve uygulamalarında dikkate alınması gerektiğini ortaya koymuştur. Eğitim sisteminde kalıcı iyileştirmeler sağlamak için her iki grup için de özelleştirilmiş yaklaşımlar geliştirilmelidir.