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TIMSS International Benchmarks of Eighth Graders in Mathematics: A Correspondence Analysis Study

İlhan Koyuncu*

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*Correspondance Details: İlhan Koyuncu, Adiyaman University, Department of Educational Sciences, Turkey, Adıyaman, Turkey.
E-mail: ilhankync@gmail.com
ORCID: https://orcid.org/0000-0002-0009-5279,

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Abstract

The aim of this study is to investigate the relationship between a variety of non-cognitive factors and the mathematics performance levels of eighth grade students in the Trends in International Mathematics and Science Study (TIMSS). The sample group consists of 4077 Turkish students who took part in TIMSS 2019. Data were collected using the student background scales in the student questionnaire and achievements tests by TIMSS practitioners. It was interpreted through correspondence analysis as an exploratory and multivariate statistical technique. Results indicated a significant correspondence between students' achievement and attitudes towards mathematics, instructional structure, school climate, and home educational resources. High-achieving students were found to express more positive attitudes, attach higher instructional clarity to mathematics lessons, encounter less disorderly behavior during mathematics lessons, and have more home educational resources. Regarding school climate, high-achieving students had less sense of school belonging than low-achieving students. As for school discipline and safety, high-achieving students faced more bullying than intermediate-level students. Results suggest that students with low mathematics achievement should be supported in terms of both educational resources and non-cognitive factors.

Keywords:

Educational Resources, TIMSS, School Climate, Correspondence Analysis, Bullying

Introduction

Mathematical knowledge covers a set of skills ranging from such basic operations as counting and calculating in everyday life to complex operations in engineering, economics, architecture, medicine, health care, etc. More or less mathematical knowledge is needed in all areas of life. Learning mathematics helps develop problem-solving skills and deal with challenges in life (Lindquist et al., 2017). The acquisition of mathematical knowledge and skills is affected by a number of factors, e.g., socioeconomic status (Akyüz, 2014; Dahl & Lochner, 2012; Sirin, 2005), school resources (Hanushek & Wößmann, 2017; Lee & Zuze, 2011; Visser et al., 2015), school climate (Cohen et al., 2009; Konishi et al., 2010; Lubienski et al., 2008; Mohammadpour, 2012), teacher quality and experience (Akiba et al., 2007; Baumert et al., 2010; Burroughs et al., 2019; Goe, 2007; Gustafsson & Nilson, 2016; Harris & Sass, 2011; Hill et al., 2005), instructional clarity (Boston, 2012; Ferguson, 2012; Nilsen et al., 2016; Schlesinger et al., 2018; Scherer & Nilsen, 2016), classroom climate (Cornelius-White, 2007; Marzano et al., 2003; Nilsen et al., 2016), attitude and intrinsic motivation (Akyüz, 2014; Becker et al., 2010; Marsh & Craven, 2006; Pajares & Miller, 1994; Vansteenkiste et al., 2008; Xiao & Sun, 2021), as well as self-concept and self-confidence (Kaskens et al., 2020; Marsh & Craven, 2006; Möller et al., 2009). Since this study aims to investigate the relationship between the students' mathematics achievement in TIMSS 2019 and various non-cognitive student background variables, the factors associated with school success were discussed under separate subheadings in line with home, school, classroom contexts and attitudes towards mathematics as included in the TIMSS 2019 Context Questionnaire Framework (Mullis & Martin, 2017).

Home Contexts

Concerning the home context, students' mathematics achievement may be associated with a range of factors, i.e. parents' education level, economic status, and home educational resources. Primarily, parental socioeconomic status (SES) has a crucial role in mathematics performance (Akyüz, 2014; Dahl & Lochner, 2012; Schreiber, 2002; Sirin, 2005; Visser et al., 2015). In a meta-analytic review, Sirin (2005) found a stronger relation between SES and mathematics achievement in comparison to other courses. Similarly, Jordan et al. (2006) found that SES is significantly associated with children's development and mathematics performance. On the other hand, parents with lower level of education are known to have considerable difficulty supporting their children's mathematics learning (Sari & Hunt, 2020). After children start primary school, however, the impact of intelligence decreases and social background (SES) becomes increasingly important.

Home environments that parents provide for their children can contribute considerably to the latter's mathematical development. Home educational resources refer to tangible and intangible assets in a home, i.e. parental education levels, parental involvement in homework, and language use at home (Juan & Visser, 2017). The relevant studies indicate that home educational resources are predictive of mathematics performance (Chiu & Xihua, 2008; Lacour & Tissington, 2011; Mohammadpour, 2012; Ölçüoğlu & Çetin, 2016; Sarı et al., 2017; Oral & McGivney, 2013; Visser et al., 2015). LeFevre et al. (2009) found that mathematics performance in the early school years is predicted positively by the frequency with which children were engaged in numeracy-related home activities (e.g., playing games involving counting, talking about numbers, using calendars, playing with calculators). Furthermore, "number talk" or the extent of mathematical language and applications at home were found to be closely associated with children's mathematics achievement (Levine et al., 2010; Ramani et al., 2015). Lehrl et al. (2020) followed 554 three-year-old children up to the age of 13 in home learning environments. Their results showed that book exposure and the quality of mathematics-related verbal interactions predicted mathematical outcomes in secondary school and that the effects were mediated through early language and arithmetic skills.

School Contexts

Concerning the school-level variables (school resources, school climate, teacher quality and experience, safety and security etc.) it can be argued that worse learning environments have a negative impact on student achievement, whereas favorable perceptions of safety and learning environments have a positive impact on mathematics achievement (Kwong & Davis, 2015). Teacher-student behaviors and mathematics achievement are affected by the safety and order of school environment, the importance attached to success at school, and the overall condition of the school (Sarı et al., 2017; Visser et al., 2015). It is seen that students who attend schools having a favorable climate achieve higher scores in mathematics (Lubienski et al., 2008; Mohammadpour, 2012). According to Fan and Williams (2018), student self-efficacy and intrinsic motivation play a mediating role in linking the perceptions of school climate with reading and mathematics achievement. Besides, students' perceptions of school climate are significantly related to achievement outcomes, and perceptions of school climate regarding teacher-student relations are significantly related to the variables of self-efficacy and intrinsic motivation. Akyüz (2014) found that student bullying and school climate of discipline and safety are significant predictors of mathematics achievement in Turkey and Finland. Students' exposure to bullying at school negatively affects their sense of school belonging (Duggins et al., 2016; Arslan, 2021). According to Arslan (2021), school bullying has a significant and negative predictive effect on youth internalizing-externalizing behaviors and school success, while school belonging mitigates the adverse impact of bullying on youth mental health and achievement.

As TIMSS 2011 international results show, successful schools are likely to have better working conditions, better facilities, and more instructional materials, e.g., books and computers (Mullis et al., 2012). Furthermore, poorly resourced schools have teachers with poor qualifications, while better-resourced schools are able to attract teachers with higher qualifications (Visser et al., 2015). Yet, there is evidence that students from disadvantaged backgrounds may have higher achievement if they attend schools where the majority of students are from advantaged backgrounds (Mullis & Martin, 2017).

Classroom Contexts

In classroom contexts, a variety of factors including teacher quality, instructional effectiveness and clarity, and suitability of classroom environment have direct or indirect impacts on students' mathematics achievement. A great deal of studies highlighted the key role of teacher quality in mathematics achievement (Akiba et al., 2007; Baumert et al., 2010; Goe, 2007; Gustafsson & Nilson, 2016; Hill et al., 2005). Burroughs et al. (2019) specified key teaching factors associated with higher mathematics achievement as follows: teacher experience, teacher professional knowledge (measured by education and self-reported preparation to teach mathematics), and teacher provision of opportunity to learn (measured by time on mathematics and content coverage). Gustafsson & Nilson (2016) found that teachers' attained level of education had effects on mathematics achievement. They identified quite substantial effects of professional development on student achievement as well. Teacher self-efficacy, as assessed by self-reports of preparedness for teaching in different domains, showed a weakly positive, but insignificant relation to student achievement.

Students' Attitudes toward Mathematics

Mathematics achievement is related to children's beliefs about mathematics (Marsh & Craven, 2006; Pajares & Miller, 1994). Xiao and Sun (2021) concluded that the group of students with the lowest mathematics anxiety and the highest motivation levels showed the highest mathematics achievement and levels of persistence, and that the groups with high mathematics interest, mathematics self-concept, and instrumental motivation showed the most frequent mathematics-related behaviours (participation in mathematical activities). An overall positive relationship is found between mathematics self-concept and mathematics achievement (Kaskens et al., 2020; Möller et al., 2009). Akyüz (2014) found that mathematics self-confidence has positive and significant effects on student achievement. The overall relationship between attitude and achievement is based on the assumption that the better a student's attitude towards a subject or task, the higher the level of achievement or performance (Schreiber, 2002). Attitude towards mathematics was the most effective factor predicting mathematics achievement of both Turkish and Korean students in TIMSS 2011 (Topçu et al., 2016). On the other hand, in a study by Geesa et al. (2019), an interesting pattern emerged referring to the conclusion that as Turkish students' mathematics achievement scores were lower than students from South Korea and the United States, their attitudes towards mathematics were higher.

Importance of the Study

In this study, students with different proficiency levels are compared over a variety of factors associated with mathematics achievement. This allows to investigate the results separately and comparatively for each competence level. Correspondence analysis, a multivariate analysis technique used, helps to achieve the purpose and highlights the importance of the current study. In addition, an investigation on Turkey, a country placed at the intermediate benchmark in TIMSS 2019 with a remarkable rising trend in recent years (MONE, 2020), is likely to offer substantial information about the relationship between achievement levels and student characteristics in an intermediate-level developing country. Since Turkey's first participation to TIMSS, its eighth grade mathematics achievement score has risen from 429 to 496, reaching the intermediate benchmark in TIMSS 2019. The rate of Turkish high-achieving students increased, while the rate of Turkish low-achieving students decreased (MONE, 2020). Turkey recorded the highest score upswing between 2015 and 2019, increasing its achievement score in almost all regions. Moreover, in the Turkish case, both male and female students increased their scores with no significant difference between the genders (MONE, 2020). TIMSS and similar international large-scale assessments have indirect influence on education reforms in Turkey (Parlak et al., 2020). Considering the impact of TIMSS and similar assessments on education policies in Turkey, this study is expected to provide educators with important feedback.

Aim of the Study

The aim of this research is to investigate the relationship between student performance in TIMSS 2019 and the scales regarding home, school, and classroom contexts, as well as attitudes towards mathematics given in the student questionnaire. To this end, answers were sought to the following questions:

What kind of correspondence is found between the eighth grade students' mathematics achievement in TIMSS 2019 and the scale scores regarding

1. *attitudes towards mathematics (confident in mathematics, like learning mathematics, and value mathematics)?*
2. *instructional clarity in mathematics lessons in association with mathematics education and curriculum, as well as disorderly behaviors during mathematics lessons in the classroom context?*
3. *home educational resources in the home context?*
4. *student bullying and sense of school belonging in the school context?*

Method

Research Design

This is a survey-type research study that describes quantitatively the background variables and performance levels of Turkish students who participated in TIMSS 2019. It is also a correlational research study as it examines the correspondence between a set of non-cognitive variables and performance levels of students. Survey studies identify the characteristics of participants by the data collected through questionnaires or interviews, whereas correlational studies investigate the relationship between two or more variables (Büyüköztürk et al., 2016).

Participants

The participants consist of 4077 eighth grade students who took part in TIMSS 2019 from Turkey. They were selected by TIMSS practitioners through purposive and stratified sampling. Of the participating students, 2012 (49.4%) were female, and 2045 (50.2%) were male. There is no data on the gender of 20 (0.5%) students. The students' ages range from 13 to 18, with an average of 14 years. In terms of achievement levels, 820 (20.1%) of the students were at Level 1, 1058 (26%) at Level 2, 979 (24%) at Level 3, and 786 (19,3%) at Level 4, and 434 (10.6%) at Level 5.

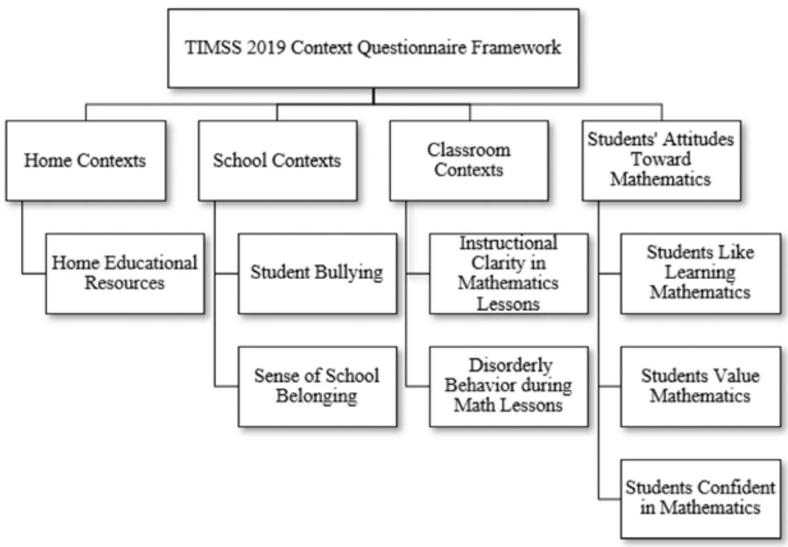
Data Collection Tools

Research data were collected through the TIMSS 2019 achievement tests and the scales within the student questionnaire. TIMSS has been conducted by the International Association for the Evaluation of Educational Achievement (IEA) every four years since 1995. It is a large-scale study in which the effectiveness of education systems in more than 60 countries is examined and compared with other countries (Mullis & Martin, 2017). Fourth and eighth grade students' performance in science and mathematics is assessed on an international scale. In TIMSS, detailed data are collected by using cognitive tests in mathematics and science, in addition to a range of scales in student, teacher, school and home contexts. A well-structured assessment process is completed through a detailed assessment framework (see Mullis & Martin, 2017) on student achievement in mathematics and science and a technical report (see Martin et al., 2020) is presented. Achievement in these domains is described at four proficiency levels as international benchmarks: low, intermediate, high and advanced. Regarding the eighth grade mathematics performance, students at the low benchmark (400-475) have basic mathematical knowledge; those at the intermediate benchmark (475-550) can apply basic mathematical knowledge in simple situations; those at the high benchmark (550-625) can apply mathematical knowledge to more complex situations, and those at the advanced benchmark (625 and above) are expected to reason, solve equations, and make generalizations in a variety of problem situations (see Mullis et al., 2020). In the present study, student performances were assessed at five proficiency levels, since a considerable percentage of students (approximately 20%) scored below 400 which is the lower bound of the low benchmark.

TIMSS mathematics achievement test covers the topics of numbers (30%), algebra (30%), geometry (20%), data and probability (20%), as well as the cognitive domains of knowing (35%), applying (40%) and reasoning (25%) (Mullis, & Martin, 2017). Achievement scores are calculated via item response theory via parameter estimations for the responses to each subtest (Martin et al., 2020). The framework of the scales used in the current study and included in the TIMSS 2019 student questionnaire is presented in Figure 1.

Figure 1.

Framework of the scales used in the study (Mullis & Martin, 2017)



According to Figure 1, the scales of confidence in mathematics, liking learning mathematics and valuing mathematics are related to attitudes towards mathematics. The scales of instructional clarity in mathematics lessons and disorderly behaviors during mathematics lessons are taken into consideration in the classroom context. Moreover, while student bullying and sense of school belonging were handled in the school context, home educational resources scale were assessed in the home context (Mullis, & Martin, 2017). The student questionnaire also includes three-category versions of those variables along with their continuous formats. The Cronbach's alpha reliability coefficients of the scales for the Turkish sample were calculated as 0.64 for home educational resources (3 items); 0.87 for disorderly behaviors during mathematics lessons (6 items); 0.85 for instructional clarity in mathematics lessons (7 items); 0.76 for sense of school belonging (5 items); 0.84 for student bullying (14 items); 0.89 for students confident in mathematics (9 items); 0.92 for students like learning mathematics (9 items); and 0.88 for students value mathematics (9 items) (Martin et al., 2020). The scales and datasets of the TIMSS 2019 are presented by Fishbein et al. (2021), and all the relevant international results can be accessed from Mullis et al. (2020).

Data Analysis

A simple correspondence analysis was used to interpret the data. It is an explanatory technique that statistically and graphically explores the correspondence in cross tabulations consisting of two or more variables (Alpar, 2020). It is a non-parametric method and does not require any assumptions except for the absence of empty cells in frequency tables. This multivariate technique is a generalized version of scatterplots which represent data in a plane with vertical and horizontal coordinates. Based on Hirschfeld's (1935) work in algebra, this technique deals with the geometric representation of distances (usually Euclidean) between profiles in rows and columns of a cross tabulation in a two-dimensional plane (Greenacre, 2017). In order to test column-row dependence, first of all, the $\chi 2$ value for test of independence is computed. Dividing the obtained $\chi 2$ value by row and column totals leads to total inertia values, i.e. the weighted average of the squares of distances from the center of profiles. A significant value of $\chi 2$ indicates a significant interaction or dependence between rows and columns in the cross tabulation (Greenacre, & Hastie, 1987). The correspondence analysis performed within the scope of the present study covers a summary table including the values of $\chi 2$ and its significance, as well as the biplot graphs with row and column profiles. Moreover, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were also reported.

In the study, IEA IDBAnalyzer software was used to obtain SPSS syntaxes to evaluate the frequency (correspondence) tables required for the correspondence analysis. This software allows to obtain the necessary statistics by using five plausible values for the mathematics field in the TIMSS data and the student weights together. Thus, within the scope of this study, all plausible values and student weights were used together to obtain the frequency tables. After obtaining these tables, it was observed that there were not any empty cells in the frequency tables. Moreover, univariate and multivariate outliers were handled by weighting columns and rows with the frequency of the observations. Finally, a series of correspondence analysis were performed for each of research problems. All analyses were carried out by using SPSS software.

Results

The summary results of the simple correspondence analysis investigating the relationship between students' mathematics performance levels and the background variables are presented in Table 1.

As seen in Table 1, a significant correspondence was found between all categories of variables and performance levels ($p < .001$). Two dimensions were elicited from all variables. The inertia values for singular values show that two dimensions explain 100% of the total variance. The eigenvalues for each variables show the correspondence between the actual graph and the resulting graph (Aksu & Coskun, 2020). Total eigenvalues showed moderate or higher correspondence for home educational resources (.571) and students confident in mathematics (.659). These values were low for all other variables. The correlation between dimensions was moderate ($.30 \leq r \leq .70$) for the variables of home educational resources and confidence in mathematics, though it was low ($-.30 \leq r \leq .30$) for other variables. For the attitude towards mathematics scales, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 2.

Although the values of contributions of each subcategory to the dimensions were given in Table 2 in detail, biplot graphs are highly practical tools to see visually the positions of the row and column points. These graphs make it possible to examine the relationship between the categories of students' background variables and performance levels. Figure 2 incorporates the biplots showing the correspondence between the scores of attitudes toward mathematics (students confident in mathematics, students like learning mathematics, students value mathematics) and performance levels.

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Figure 2 shows that students at Level 1 somewhat like learning mathematics, those at Levels 2 and 3 do not like learning mathematics, and those at Levels 4 and 5 like learning mathematics very much. Likewise, students at Level 1 do not value mathematics, those at Levels 2 and 3 somewhat value mathematics, and those at Levels 4 and 5 strongly value mathematics. Students at Levels 1, 2 and 3 are not confident in mathematics, whereas those at Level 4 are somewhat confident in mathematics, and those at Level 5 are very confident in mathematics.

For the scales in the classroom context, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 3.

Figure 3 indicates that students at Level 1 encounter disorderly behaviors during some mathematics lessons, whereas those at Level 2 observe such behaviors during most lessons, and those at Levels 3, 4 and 5 during a few or no lessons. Instructional clarity in mathematics lessons was low and moderate according to students at Level 1 and Level 2. Students at Levels 3, 4, and 5 reported high instructional clarity in mathematics lessons.

For home educational resources, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 4.

Table 1.
Analysis summary

						Proportion of Inertia		Confidence Singular Value	
									Correlation
Scale	Dimension	Singular Value	Inertia	Chi Square	Sig.	Accounted For	Cumulative	Std. Deviation	2
Home educational resources	1	.412	.170			.870	.870	.014	.596
	2	.159	.025			.130	1.000	.017	
	Total	.571	.195	790.112	.000*	1.000	1.000		
Sense of school belonging	1	.078	.006			.858	.858	.016	-.045
	2	.032	.001			.142	1.000	.016	
	Total	.110	.007	28.681	.000*	1.000	1.000		
Student bullying	1	.115	.013			.922	.922	.016	.101
	2	.033	.001			.078	1.000	.016	
	Total	.148	.014	57.991	.000*	1.000	1.000		
Students like learning mathematics	1	.302	.091			.962	.962	.015	.011
	2	.060	.004			.038	1.000	.017	
	Total	.362	.095	376.024	.000*	1.000	1.000		
Instructional clarity in mathematics lessons	1	.189	.036			.980	.980	.015	-.006
	2	.027	.001			.020	1.000	.016	
	Total	.216	.036	147.245	.000*	1.000	1.000		
Disorderly behaviour during mathematics lessons	1	.087	.008			.905	.905	.015	-.002
	2	.028	.001			.095	1.000	.016	
	Total	.115	.008	34.130	.000*	1.000	1.000		
Students confident in mathematics	1	.530	.281			.944	.944	.013	.346
	2	.129	.017			.056	1.000	.018	
	Total	.659	.298	1193.978	.000*	1.000	1.000		
Students value mathematics	1	.224	.050			.989	.989	.015	.015
	2	.024	.001			.011	1.000	.013	
	Total	.248	.051	202.977	.000*	1.000	1.000		

** Significant at the level of .001 (8 degrees of freedom).*

Table 2.
Overview of row and column profiles for attitude scales

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Students Like Learning Mathematics Lessons	Row Points[a]	Very Much	.298	.786	.108	.053	.643	.059	.996	.004	1.000
		Somewhat	.406	-.176	-.284	.006	.044	.551	.650	.350	1.000
		Do Not Like	.296	-.552	.279	.027	.314	.390	.950	.050	1.000
		Active Total	1.000			.086	1.000	1.000			
	Column Points[a]	Level 1	.206	-.456	-.406	.014	.149	.573	.859	.141	1.000
		Level 2	.245	-.414	.267	.013	.146	.294	.921	.079	1.000
		Level 3	.246	-.134	.145	.002	.015	.087	.804	.196	1.000
		Level 4	.191	.527	-.115	.015	.184	.043	.990	.010	1.000
		Level 5	.112	1.135	.041	.042	.505	.003	1.000	.000	1.000
		Active Total	1.000			.086	1.000	1.000			
Students Value Mathematics	Row Points[a]	Strongly	.475	.471	.039	.023	.478	.046	1.000	.000	1.000
		Somewhat	.405	-.322	-.124	.009	.191	.404	.990	.010	1.000
		Do Not Value	.120	-.781	.265	.016	.331	.549	.992	.008	1.000
		Active Total	1.000			.049	1.000	1.000			
	Column Points[a]	Level 1	.207	-.509	.055	.012	.242	.041	.999	.001	1.000
		Level 2	.244	-.344	-.083	.006	.131	.111	.996	.004	1.000
		Level 3	.247	-.025	.107	.000	.001	.186	.440	.560	1.000
		Level 4	.191	.488	-.191	.010	.206	.454	.990	.010	1.000
		Level 5	.112	.910	.168	.021	.421	.208	.998	.002	1.000
		Active Total	1.000			.049	1.000	1.000			
Student Confident in Mathematics	Row Points[a]	Very	.151	1.467	-.399	.171	.631	.218	.984	.016	1.000
		Somewhat	.343	.218	.448	.016	.032	.625	.527	.473	1.000
		Not Confident	.506	-.587	-.185	.092	.338	.157	.979	.021	1.000
		Active Total	1.000			.278	1.000	1.000			
	Column Points[a]	Level 1	.207	-.619	-.110	.041	.154	.023	.993	.007	1.000
		Level 2	.244	-.522	-.209	.035	.129	.096	.967	.033	1.000
		Level 3	.246	-.190	.143	.005	.017	.046	.892	.108	1.000
		Level 4	.191	.656	.538	.048	.159	.502	.874	.126	1.000
		Level 5	.112	1.577	-.572	.148	.541	.334	.973	.027	1.000
		Active Total	1.000			.278	1.000	1.000			

a. Symmetrical normalization

Figure 2.
Attitude scales

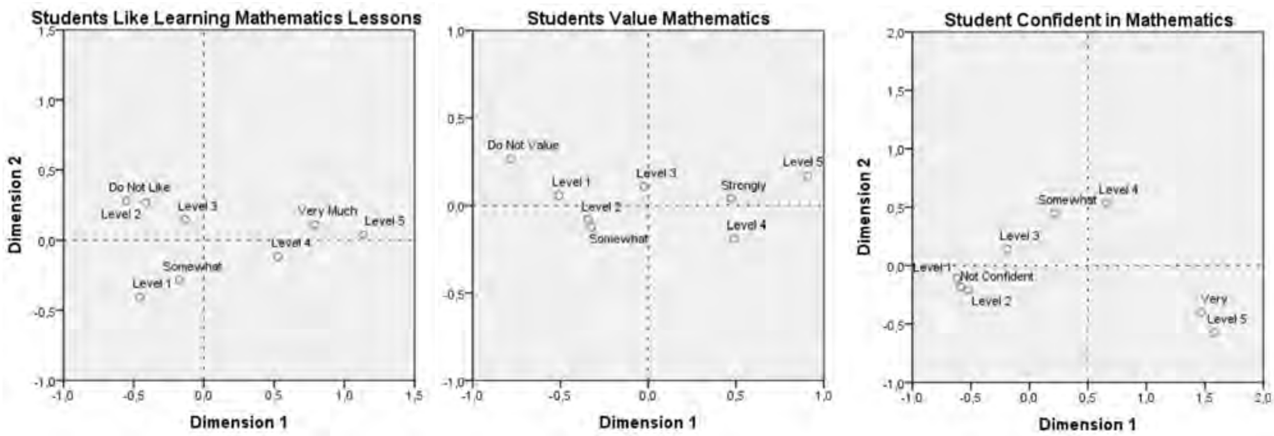


Table 3.
Overview of row and column profiles for the scales in the classroom context

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Disorderly Behavior during Math Lessons	Row Points[a]	Few or No Lessons	.233	.530	.012	.006	.765	.002	1.000	.000	1.000
		Some Lessons	.654	-.154	-.069	.001	.182	.164	.957	.043	1.000
		Most Lessons	.113	-.199	.376	.001	.052	.834	.555	.445	1.000
		Active Total	1.000			.008	1.000	1.000			
	Column Points[a]	Level 1	.207	-.484	-.064	.004	.567	.044	.996	.004	1.000
		Level 2	.245	-.117	.162	.000	.039	.335	.699	.301	1.000
		Level 3	.246	.147	-.168	.001	.062	.362	.774	.226	1.000
		Level 4	.190	.312	-.041	.002	.216	.017	.996	.004	1.000
		Level 5	.112	.296	.203	.001	.115	.241	.904	.096	1.000
		Active Total	1.000			.008	1.000	1.000			
Instructional Clarity in Mathematics Lessons	Row Points[a]	High	.671	.295	.016	.011	.318	.011	1.000	.000	1.000
		Moderate	.268	-.533	-.136	.014	.417	.315	.994	.006	1.000
		Low	.061	-.891	.416	.009	.265	.674	.982	.018	1.000
		Active Total	1.000			.034	1.000	1.000			
	Column Points[a]	Level 1	.207	-.676	.012	.017	.515	.002	1.000	.000	1.000
		Level 2	.244	-.182	-.126	.002	.044	.249	.960	.040	1.000
		Level 3	.247	.138	.180	.001	.026	.509	.873	.127	1.000
		Level 4	.190	.440	.023	.007	.201	.006	1.000	.000	1.000
		Level 5	.112	.591	-.181	.007	.214	.234	.992	.008	1.000
		Active Total	1.000			.034	1.000	1.000			

a. Symmetrical normalization

Figure 3.
Mathematics curriculum and instruction

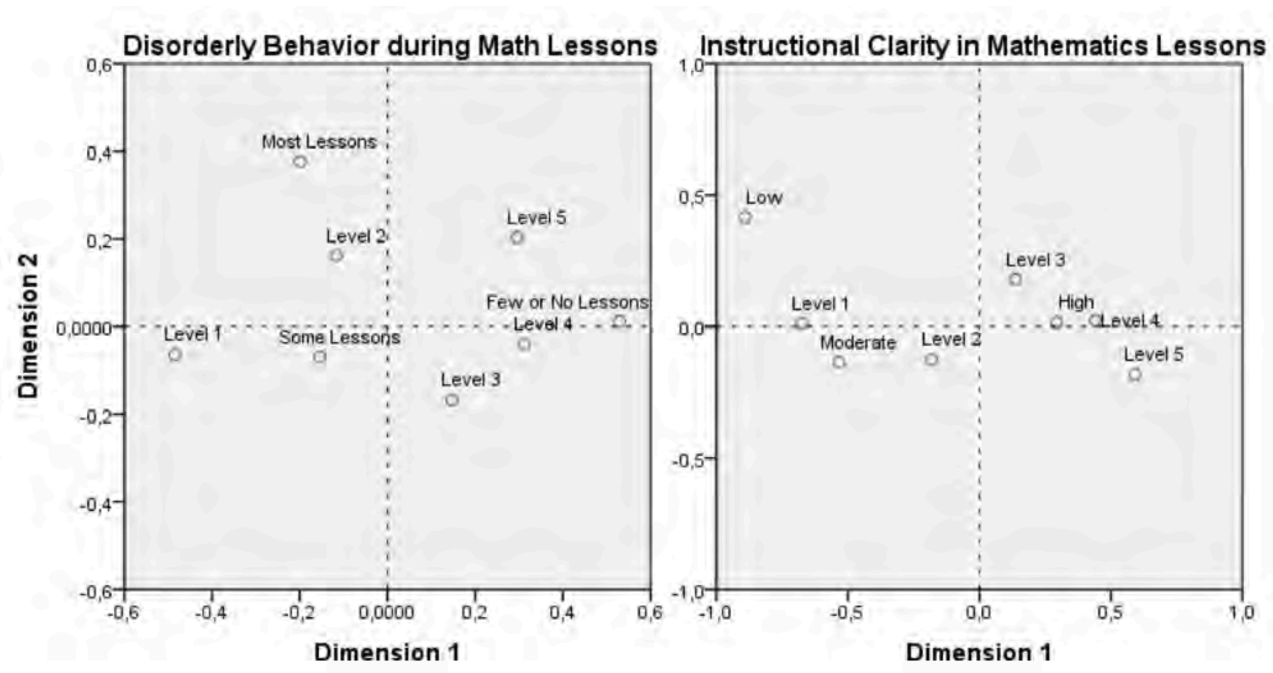


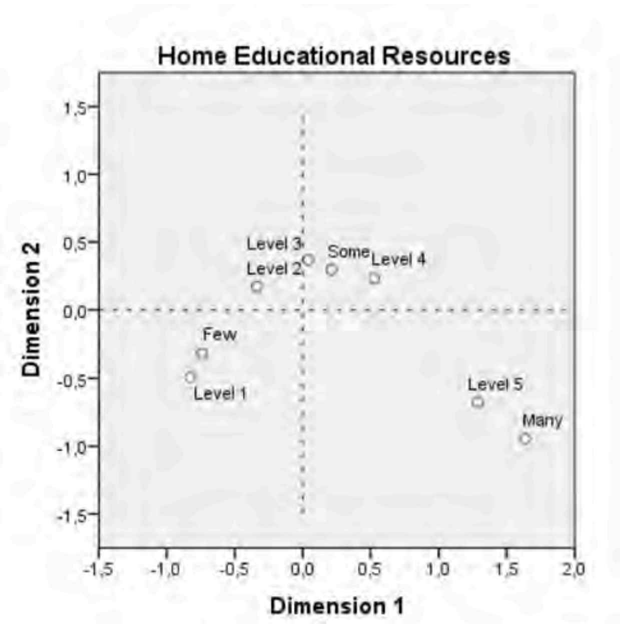
Table 4.
Overview of row and column profiles for home educational resources

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Home Educational Resources	Row Points[a]	Many	.074	1.636	-.946	.091	.488	.437	.889	.111	1.000
		Some	.594	.210	.297	.019	.064	.342	.572	.428	1.000
		Few	.332	-.742	-.318	.080	.448	.220	.936	.064	1.000
		Active Total	1.000			.190	1.000	1.000			
	Column Points[a]	Level 1	.207	-.827	-.493	.065	.347	.330	.883	.117	1.000
		Level 2	.245	-.338	.172	.012	.068	.047	.912	.088	1.000
		Level 3	.246	.040	.370	.005	.001	.221	.030	.970	1.000
		Level 4	.190	.526	.233	.023	.129	.068	.932	.068	1.000
		Level 5	.112	1.288	-.675	.083	.454	.334	.907	.093	1.000
		Active Total	1.000			.190	1.000	1.000			

a. Symmetrical normalization

Although the values of contributions of each subcategory to the dimensions were given in Table 4 in detail, biplot graphs are highly practical tools to see visually the positions of the row and column points. Figure 4 includes the biplots showing the correspondence between performance levels and the scale scores regarding home educational resources in the home context.

Figure 4.
Home educational resources



According to Figure 4, students having few resources are placed at Level 1, those having some resources at Levels 2, 3 and 4, and those having many resources at Level 5.

For the scales in the school context, the score of each subcategory in dimensions, mass and inertia of each subcategory, the contribution of the points to the inertia of dimensions, and the contribution of the dimensions to the inertia of points were given in Table 5.

The contributions of each subcategory to the dimensions were interpreted through the biplot graphs. The biplots showing the correspondence between performance levels and the scale scores regarding student bullying and sense of school belonging in the school context are presented in Figure 5.

Figure 5 shows that students at Levels 1 and 2 have some sense, those at Level 3 and Level 4 have high sense, and those at Level 5 have little sense of school belonging. It is seen that students at Level 1 face bullying averagely once a week or once a month, those at Level 2 once a month, whereas those at Levels 3, 4 and 5 never or almost never face bullying.

Discussion

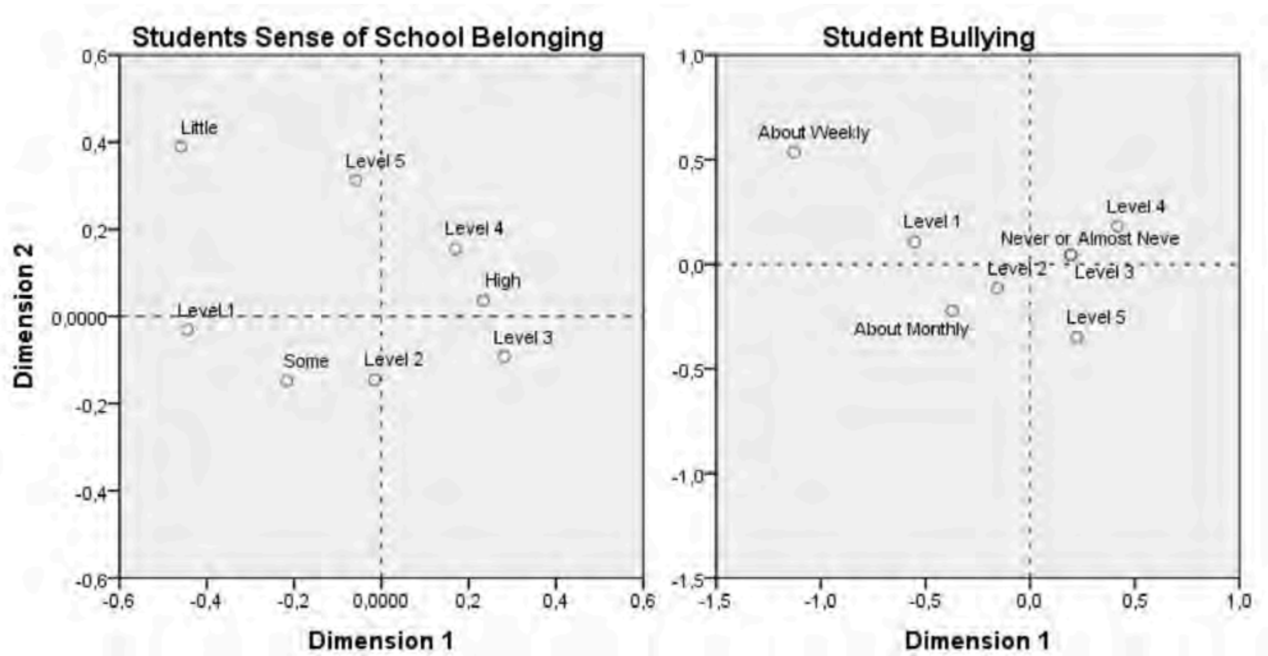
In this study, the relationship between students' performance levels in mathematics and background variables regarding classroom, home and school contexts was investigated through correspondence

Table 5.
Overview of row and column profiles for the scales in the school context

				Score in Dimension Inertia			Contribution				
							Of Point to Inertia of Dimension		Of Dimension to Inertia of Point		
			Mass	1	2	Inertia	1	2	1	2	Total
Student Bullying	Row Points[a]	Never or Almost Never	.713	.196	.043	.003	.235	.052	.989	.011	1.000
		About Monthly	.243	-.373	-.224	.004	.289	.468	.926	.074	1.000
		About Weekly	.044	-1.128	.536	.007	.476	.481	.952	.048	1.000
		Active Total	1.000			.014	1.000	1.000			
	Column Points[a]	Level 1	.206	-.552	.106	.007	.538	.090	.992	.008	1.000
		Level 2	.245	-.156	-.115	.001	.051	.125	.892	.108	1.000
		Level 3	.247	.193	.044	.001	.079	.018	.988	.012	1.000
		Level 4	.190	.417	.181	.004	.284	.241	.959	.041	1.000
		Level 5	.112	.225	-.350	.001	.048	.526	.648	.352	1.000
		Active Total	1.000			.014	1.000	1.000			
Students Sense of School Belonging	Row Points[a]	High	.531	.234	.037	.002	.438	.031	.991	.009	1.000
		Some	.376	-.217	-.148	.001	.266	.357	.860	.140	1.000
		Little	.093	-.460	.390	.002	.296	.612	.800	.200	1.000
		Active Total	1.000			.005	1.000	1.000			
	Column Points[a]	Level 1	.206	-.444	-.031	.003	.614	.009	.998	.002	1.000
		Level 2	.245	-.016	-.145	.000	.001	.225	.032	.968	1.000
		Level 3	.247	.282	-.092	.001	.296	.091	.964	.036	1.000
		Level 4	.190	.170	.156	.000	.083	.202	.774	.226	1.000
		Level 5	.112	-.058	.313	.000	.006	.474	.091	.909	1.000
		Active Total	1.000			.005	1.000	1.000			

a. Symmetrical normalization

Figure 5.
Scales in the school context



analysis. Research results indicate a significant relationship between performance levels and attitudes towards mathematics, instructional structure, school climate, and home educational resources. The results are discussed in detail below for each of research problem separately.

First of all, according to the study results, low-achieving students had lower levels of confidence in mathematics, and they slightly like and value mathematics. In parallel, it was found that high-achieving students had higher levels of positive attitudes. Other studies also show that students' beliefs about mathematics support their mathematics achievement (Pajares & Miller, 1994; Xiao & Sun 2021). For example, Şahin and Boztunç Öztürk (2018) found that liking mathematics is positively related to mathematics achievement. Positive beliefs are expected to lead students to set aside more time, put more effort, and succeed in mathematics. On the contrary, relevant false beliefs and negative experiences can cause mathematics anxiety over time (Ashcraft & Krause, 2007; Li et al., 2021). For example, Fırat and Erdem (2019) found that the fourth grade students with difficulties in learning mathematics had mathematics anxiety and prejudices towards mathematics, even though they had not experienced difficulty in affective domain during the first grade. A negative relationship is found between mathematics achievement and anxiety (Barroso et al., 2021; Casanova et al., 2021). We therefore argue that early diagnosis and intervention are crucial to prevent false beliefs in mathematics from turning into mathematics anxiety. Early anxieties may snowball and eventually lead students to avoid mathematics classes and mathematics-related career choices (Ramirez et al., 2013).

Second, while low-achieving students found instructional clarity in mathematics lessons low, high-achieving ones found it high. The relationship between the quality of mathematics instruction (clarity and supportive climate) and mathematics achievement was highlighted by several studies (Boston, 2012; Schlesinger et al., 2018; Scherer & Nilsen, 2016). According to Nilsen et al. (2016), the quality of mathematics instruction depends on (a) supportive climate, (b) instructional clarity, (c) cognitive activation, and (d) classroom management. They relate these dimensions to teacher qualities (education, preparation, experience, etc.). In this respect, it is possible to argue that teacher qualities are of importance for the clarity of mathematics. Higher achievement among students from socioeconomically advantageous schools can be explained in part by the fact that such schools have better quality teachers (Mullis & Martin, 2017). Ersan and Rodriguez (2020) found that associations between instructional quality and mathematics scores were significant even after controlling for the impact of SES. From this point of view, we can underscore the unique impact of mathematical clarity on achievement. Another result found in the present study supporting this claim was the fact that low-achieving students faced disorderly behaviors during mathematics lessons more often than high-achieving students as for the classroom climate.

Third, home educational resources are associated with student achievement in TIMSS. Accordingly, low-achieving students reported to have insufficient home educational resources, whereas high-achieving students had sufficient resources. Previous studies also indicated that home educational resources and attitudes towards mathematics both positively and significantly predict student achievement (Geesa et al., 2019; Özkan, 2018). For instance, Özkan (2018) found that students from the top five countries in mathematics achievement have more home educational resources and opportunities than Turkish students. Even among the top five countries, the average achievement of students with more home educational resources and opportunities was found higher than that of students with less resources and opportunities. Some empirical studies show that students who receive more support from their parents have higher mathematics achievement and more favorable attitudes towards mathematics than students who receive less support (Cai et al., 1999). This can be explained by parental socioeconomic status and education level (Sari & Hunt, 2020; Sirin, 2005). Studies have found a significant relationship between parental education level and children's mathematics achievement (Kaleli-Yılmaz, & Hanci, 2016). For instance, the education level of students' mother and if students come from a home with many books have a clear influence on students' mathematics performance (Wiberg, 2019). Parents' mathematical activities at home (Levine et al., 2010; Lehrl et al., 2020) and their attitudes towards mathematics (Mohr-Schroeder et al., 2017; Sheldon & Epstein, 2005) can contribute to children's mathematical skills and attitudes towards mathematics. According to Soni and Kumari (2017), parents' mathematics anxiety and attitude act as precursors to their children's mathematics anxiety and attitude and further influence the mathematics achievement of their children.

Fourth, in terms of school climate, an interesting result regarding the Turkish sample in TIMSS is that high-achieving students had less sense of school belonging than low-achieving students. In their meta-analytic review, Korpershoek et al. (2020) found a small positive relationship between achievement levels and school belonging. In another study using data from Turkey as well, Korean students who reported that they liked school, felt safe, and had sense of school belonging were more successful in science and mathematics. On the contrary, when Turkish students' sense of school belonging increased, their science and mathematics achievement decreased (Topçu et al., 2016). As a matter of fact, a number of studies found a significant relationship between sense of school belonging and mathematics achievement (Hughes et al., 2015; Smith et al., 2021). Sense of school belonging is important for students' academic achievement, well-being and mental health (Allen et al., 2018; Arslan, 2021). Moreover, according to Korpershoek et al. (2020), sense of school belonging negatively predicts absence and dropout rates. This finding needs to be investigated in the context of Turkish education system. Ahmadi et al. (2020) showed that student-level variables, such as socioeconomic status, parental involvement, and peer support are related to sense of school belonging. In addition, school-level variables including sense of fairness and teacher-student relations could explain the variance in school belonging. Therefore, the contradictory result in the present study can be attributed to several reasons. First of all, it can be explained by the fact that successful students are disliked and excluded by their peers in school environments. It is known that children who excel in mathematics and other fields are not accepted by typically developing peers and are even exposed to peer bullying (Peterson & Ray, 2006). Concerning the school discipline and safety, a finding of the current study is that high-achieving students face more bullying compared to intermediate-level students. The fact that these students encounter bullying averagely once a month may have harmed their sense of school belonging. Secondly, teacher quality may be another reason (Kiefer et al., 2015). Teachers need to have further professional and pedagogical knowledge in order to support successful students educationally, socially and emotionally inside and outside the classroom. Teachers' deficiencies in these fields and inability to develop bilateral relations with students may weaken students' sense of school belonging (Ibrahim & El Zaatari, 2020).

Conclusion

In conclusion, there are strong associations between students' achievement levels and their attitudes towards mathematics, approaches to mathematics instruction, possession of sufficient educational resources, as well as perceptions of school climate and discipline. Overall, it is seen that low-achieving students have a negative attitude towards mathematics, find the mathematics instruction unclear and the classroom environment unfavorable, and their educational resources are insufficient. This situation indicates that students' failure in mathematics is closely related to not only insufficient resources, but also negative attitudes and approaches.

Limitations and Suggestions

This study has some limitations due to its quantitative nature. First, it is limited to the variables included in the TIMSS student questionnaire and used in the study. Future studies can investigate the relationship between student achievement and teacher- and school-level variables. Second, the scales in TIMSS consist of students' self-reported information. The results are therefore limited to student statements. Third, this study is limited to the sample of Turkish eighth grade students. The results of this study can be repeated and compared with similar conditions for other grade levels and for different countries. Fourth, the technique of correspondence analysis was used in this study. Future studies can investigate the relationship between student achievement and TIMSS scales via different analysis techniques. Finally, there are more low-achieving Turkish students in the TIMSS. This situation should be taken into consideration in the evaluation of the results of this study and in future studies.

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