IJPES
www.ijpes.com
International Journal of Psychology and Educational Studies
ISSN: 2148-9378

The Effect of School and Student-Related Factors on PISA 2015 Science Performances in Turkey

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ARTICLE INFO

Article History
Received 19.02.2021
Received in revised form 28.03.2021
Accepted 14.04.2021
Available online: 21.04.2021

ABSTRACT

The Program for International Student Assessment (PISA) is a research project conducted by the Organization for Economic Co-operation and Development, which evaluates the knowledge and skills gained by 15-year-old students over three-year terms. Within this study's' scope, the PISA 2015 data were analysed to determine whether school-related factors [including the schools' economic, social, and cultural status (ESCS)] were related to Turkish students' science performances. Due to its nested structure, the released PISA 2015 data were analysed using the hierarchical linear model (HLM). Two models were considered to examine how Aggregated ESCS at the school level makes a difference. Thereby in model 1 shortage of educational material, staff shortage, student behaviours, and teacher behaviours were included in the analysis; in addition to these variables listed, aggregated ESCS was also added to the analysis in Model 2. The results of the analysis revealed that school-related factors - in particular, staff shortage, student behaviours, and aggregated ESCS indexes - were statistically related to students' science performances. When the aggregated ESCS was controlled, it is observed that the school-level variables had a higher effect on students' science performances.

Keywords:
HLM, PISA, science literacy, science performance, school resources, school ESCS

1. Introduction

The International Student Assessment (PISA) Program is an international comparative student surveillance and assessment process conducted every three years by the Organization for Economic Co-operation and Development (OECD) to determine students' success levels aged 15 years in the participating countries in science, mathematics, and literacy. This assessment allows cross-country comparisons in terms of skills in science, mathematics, and literacy and the level of performance of students. Additionally, PISA also aggregates other data related to different variables considered to influence the quality of education, such as parents, schools, and economic, social, and cultural status (ESCS). PISA focuses on a different skill in each application, for example, reading skills, mathematics literacy, or science literacy (Bybee, Fensham, & Laurie, 2009).

Science literacy, one of the focal subjects of PISA, is defined as "*the ability to engage with science-related issues*" (OECD, 2016); thus, through this item, PISA aims to measure scientific competencies, understandings, and attitudes toward science (Bybee et al., 2009). PISA science literacy is based on the assumption that a student's specific science-related response requires skills and knowledge and depends on their willingness to engage in the topic (OECD, 2016). Although many variables affect students' science literacy levels and science performances, when the literature is examined, one of the most important factors determining students'

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Citation: Yetişir, M. İ. & Batı, K. (2021). The effect of school and student-related factors on PISA 2015 science performances in Turkey. *International Journal of Psychology and Educational Studies, 8*(2), 170-186.
https://dx.doi.org/10.52380/ijpes.2021.8.2.433

literacy levels seems to be the ESCS (Perry, 2010). However, it is known that students who come from families with low ESCS have a lower risk of stroke (Stacey, 2010). Additionally, student affective characteristics - such as motivation, self-efficacy, readiness, self-control, and epistemological beliefs as well as school-related factors including quality of educational materials, qualification of teachers, and physical characteristics (Çelebi, 2010; Karabay, 2013) also play an important role in determining student performances. Sun, Bradley, and Akers (2012) also pointed out that the value and positive attitudes of parents directly affect students' science performances. The results obtained from the Turkish samples were similar to those from other OECD countries, showing that parents' education level and variables, such as the number of books at home, significantly impact students' science performance (Erbaş, 2005; Karabay, 2012, 2013). Although ESCS cannot directly explain this effect, this view is also supported by the findings of the research conducted by Lin, Hong, and Huang (2012), who reported that emotional factors, such as interest and entertainment, have a significant influence on the literacy levels of students. This raises another question, "*is ESCS a consistent variable in explaining the science performance and literacy levels of students?*". According to Çeçen (2015), the answer is yes. Çeçen evaluated the PISA results for 2003, 2006, 2009, and 2012 through a survey and found that ESCS was a good predictor of student performances and literacy levels.

The impact of students' family backgrounds, socioeconomic status (SES), and school-related factors on their academic performances have been an important issue since the Coleman Report's publication (Coleman et al., 1966). Under Coleman's leadership, this study conducted in the USA argued that SES variables are more important than the school resources in determining the students' educational achievements. The first serious objections to this research came with the work of Edmonds (1979), who focused on schools that were successful despite their poverty (low SES) and, later, Hanushek (1997), who supported Coleman's findings that no strong or consistent relationship existed between school inputs and student performances. Similarly, Heyneman and Loxley (1983) reported that, while the variance of school-related variables in high-income countries accounted for 35% of the students' performances, this was 18% in low-income countries. They also stated a negative and significant relationship between school-related factors and the variance rate explained by GNP per capita. This finding, described as the "Heyneman-Loxley Effect", provided concrete evidence that variation in school resource quality may be more important than variations in family input in low and middle-income countries (Bouhlila, 2015). Despite the critics (Riddell 1989a, 1989b), these findings have been the basis of discussions in the interpretation of TIMSS results from 2002 to 2010 (Baker, Goesling, LeTendre, 2002; Bouhlila, 2015; Heyneman, & Lee, 2012). According to Baker et al. (2002), the Heyneman-Loxley Effect demonstrates the strength of schooling at the social level and families' socioeconomic status and the social impact such as school quality on students' academic achievements. Even if they are not as effective as the controversial effect of school resources and family history on success (Riddell 1989a), it explains the differences in a countries' science and mathematics performances (Baker et al., 2002), such as Turkey. The improvements made in the quality of school-related factors have positively impacted student achievements (Authors, 2013).

School-related factors expressed as variables related to schools' quality are school environment, school ESCS, staff shortage, and educational material shortage. The concept that examines these variables' effect on students' academic achievement is the "opportunity to learn" (OTL). Since the 1960s, OTL has been one of the most important concepts in explaining schools' impact on students' success. Carroll (1963) emphasised that OTL is one of the school learning models' critical structures and defined it as the time allocated to the student to learn a particular task. In the following years, the OTL concept expanded to include different effects on the schools' success. Today, OTL refers to conditions or possibilities that promote learning in schools and classrooms, such as curricula, learning materials, physical conditions, teachers and their teaching experiences, as educational programs and a policy tool (Cooper, & Liou, 2007; Newman, Myers, Newman, Lohman, & Smith, 2000; Wijaya, 2017). OTL argues that differences in students' (or schools) academic achievements are due to unequal learning conditions rather than students' abilities (Schwartz, 1995). Therefore, OTL is considered an essential concept to investigate possible causes of students' poor performances (Brewer, & Stasz, 1996; Hiebert & Grouws, 2007) and explain the differences between student performances in international comparative studies of countries with different education systems (Schmidt, McKnight, Valverde, Houang, & Wiley, 1997; Valverde, Bianchi, Wolfe, Schmid, & Houang, 2002).

It is known that ESCS is one of the greatest predictors of student academic achievements (Şirin, 2005). However, it is the ESCS of the individual and the ESCS of the school that has this effect (Ho, & Willms, 1996; OECD, 2004; Rumberger & Palardy, 2005; Şirin, 2005; Willms, 1999). Although Coleman's findings have been suggested to have some problems (Gamoran, & Long, 2007), many studies have shown that features such as school ESCS, school environment, and school resources have an impact on student academic achievements (Fuller, & Clarke, 1994; Greenwald, Hedges, & Laine, 1996; Lee, 2000; Rutter, & Maughan, 2002; Van Ewijk, & Sleegers, 2010). Perry and McConney (2010) suggested that students may have higher performance levels in a school with high ESCS, and their performances may be reduced if the school ESCS is low. This indicates that schools' average ESCS has a higher correlation with students' ESCS in explaining students' academic achievements (Perry, & McConney, 2010). Therefore, to determine students' performances within PISA's scope, the ESCS of schools must be calculated and controlled in the PISA analyses. Although the literature states that schools ESCS variables and the schools quality can have a significant impact on students' science performances (Lee, 2000; Rutter, & Maughan, 2002; Van Ewijk, & Sleegers, 2010), Schleicher (2009) states that directly linking countries low performances to ESCS would be wrong. He emphasised that some economically lagging countries have achieved success in PISA by reducing inter-school variance. Therefore, the extent to which school ESCS variables can affect students' science performances is an important question, especially in countries with high inter-school variances, such as Turkey. Examining the school ESCS variable's role in student performances may offer a different perspective, especially considering that schools benefit from the government-distributed resources at similar rates due to the Turkish education system's central structure. From this perspective, this research aims to determine (1) how students' science performances are affected by school-related and student-related factors in Turkey and (2) given that the school ESCS is calculated and determined as an independent variable, how students' science performance is affected by school-related factors.

2. Method

Data Source

In this study, the data obtained from PISA 2015 were used. In PISA studies, the preferred sample design is the two-step stratified sampling. In the first step, the individual schools in which 15-year-old students are enrolled are sampled. In the second step, students are selected from the schools identified in the first step (OECD, 2016). The number of samples per school cannot be less than 20 (OECD 2016). Data were collected from 187 school principals and 5895 students to answer the research questions. Thus, the data source is nested and consists of two levels; student level (*level 1*) and school level (*level 2*). PISA 2015 student and school questionnaires and student science performance tests were used as data collection sources within the research scope. All variables included in the study are presented in Table 1 and Table 2 below with metrics, definitions, and Cronbach Alpha values. Additionally, the descriptive statistics for all variables in the study are provided separately in Table 3.

Dependent Variables

In this study, students' science performances were determined as a dependent variable. There are two dimensions of the science test in PISA. The content dimension covers physics, chemistry, biology, and earth science. In contrast, the cognitive dimension encompasses knowing, applying, and reasoning skills. The item response theory method is used to determine students' science performances (Martin, Mullis, Foy & Stanco, 2012). Additionally, ten plausible values were calculated for each student by PISA. All plausible values were used in the analysis carried out in this study.

Plausible values are used to show the students' science performances. In PISA's scope, instead of obtaining a point estimate, the probable values of a student are estimated to have a probability for each of these values. Plausible values are obtained randomly from this (estimated) distribution for each student (OECD, 2009; Wu, 2005). This definition shows that plausible values are not the actual individual test scores collected at the student level. Although this may seem to be a limitation, very detailed statistical techniques are used to control this within the PISA study.

Independent Variables

In the PISA study context, two background questionnaires are used to determine factors that affect students' performances; the school questionnaire was distributed to the school's principals, and the student questionnaire was distributed to all of the participating students. According to the data structure, independent variables were selected from these two sources - the student questionnaire (Level 1) and the school questionnaire (Level 2).

Level 1 (student-level) independent variables:

Gender, arriving late for school, skipping school, economic, social, and cultural status (ESCS), teacher support, and disciplinary climates were investigated at the student level. Student questionnaires collected the student-level independent variables, and these variables are shown in Table 1 below.

Disciplinary Climate: Disciplinary climate index (DISCLISCI) was constituted from students' reports on how often ("every lesson", "most lessons", "some lessons", "never or hardly ever") about the following situations: "Students don't listen to what the teacher says"; "There is noise and disorder"; "The teacher has to wait a long time for students to quiet down"; "Students cannot work well"; and "Students don't start working for a long time after the lesson begins".

Teacher support to students: The index of teacher support to students (TEACHSUP) has been calculated from students' responses ("every lesson", "most lessons", "some lessons", "never or hardly ever") on expressions such as "The teacher shows an interest in every student's learning"; "The teacher gives extra help when students need it"; "The teacher helps students with their learning"; "The teacher continues teaching until students understand the material"; and "The teacher gives students an opportunity to express their opinions".

PISA index of ESCS: The ESCS index "*was derived, as in previous cycles, from three variables related to family background: highest parental education, highest parental occupation, and home possessions, including the number of books at home*" (OECD, 2016c, p. 243).

Skipping school: PISA asked students how many school days they skipped in the last two weeks before the assessment.

Skipping some classes: PISA asked students how many lessons they had skipped in the last two weeks before the assessment.

Arriving late for school: PISA asked students how many times they were late to school in the last two weeks before the assessment.

Table 1. *Student-Level Scale Indices and Variables*

Variable/Scale	α	Items	Response
Disciplinary climate (5 items)	0.893	- "Students don't listen to what the teacher says;" - "There is noise and disorder " - "The teacher has to wait a long time for students to quiet down" - "Students cannot work well" - "Students don't start working for a long time after the lesson begins"	"every lesson", "most lessons", "some lessons", "never or hardly ever"
Teacher support to students (5 items)	0.915	- "The teacher shows an interest in every student's learning" - "The teacher gives extra help when students need it" - "The teacher helps students with their learning"	

		- “The teacher continues teaching until students understand the material” - “The teacher gives students an opportunity to express their opinions”	
Number of times <”skipped a whole day”>			“never”, “one or two times”, “three or four times” or “five or more times”
Number of times <”skipped some classes”>			
Number of times <”arrived late for school”>			
Index of ESCS (economic social and cultural status)			
Gender (Female=1, Male=2)			

Level 2 (school-level) independent variables:

School resources (staff shortage and educational material shortage), school climate (teacher behaviours and student behaviours), and aggregated ESCS were selected for the analytic model for the school level. The school-level independent variables are shown in Table 2 below.

School Resources: PISA asked eight questions to measure school principals' perceptions of school factors affecting teaching quality. STAFFSHORT was examined under four different factors: lack of teaching staff, inadequate teaching staff, lack of assistant staff, and inadequate or inadequately assisted staff. Lack of educational materials (e.g. textbooks, IT equipment, library or laboratory materials), insufficient or low-quality educational materials, lack of physical infrastructure (e.g. building, floor, heating/cooling, lighting, and acoustic systems) and poor or poor quality physical infrastructure. Positive values in these indices indicate that school principals think that the quality of education in their schools affects the quantity and/or quality of these resources to a greater extent than the OECD average.

School climate: This index measured school principals 'perceptions about the school climate, especially teachers' and students 'perceptions that could prevent students' learning. The student behaviour index (STUBEHA), which prevented learning, consisted of five dimensions: students' degree of preparation, students who did not skip courses, students who did not respect teachers, students who used alcohol or illegal drugs, and those who intimidated and forced other students. The teacher behaviour index (TEACHBEHA), which prevents learning, consisted of five dimensions: meeting the individual needs of students, absenteeism, resisting change, being too strict towards the students, and not being prepared for the lessons.

Aggregated ESCS: In the PISA dataset, the ESCS variable was only available at the student level, and there was no calculated data for ESCS at the school level. A new variable called "aggregated ESCS" was produced at the school level by aggregating the student-level ESCS values using the SPSS software package to use the ESCS variable at the school level in the analyses. From the individual ESCS index score of the students attending the same school, an average ESCS score was generated for each school.

Table 2. *School-level Scale Indices*

Variable/Scale	α	Items	Response
Staff shortage (4 items)	0.804	- “a lack of teaching staff” - “inadequate or poorly qualified teaching staff” - “a lack of assisting staff” - “inadequate or poorly qualified assisting staff”	“not at all”, “very little”, “to some extent” and “a lot”
Shortage of educational material (4 items)	0.905	- “a lack of educational material” - “inadequate or poor quality educational material” - “a lack of physical infrastructure” - “inadequate or poor quality physical infrastructure”	

Student Behaviour (5 items)	0.751	- "student truancy" - "students skipping classes" - "students lacking respect for teachers" - "students using alcohol or illegal drugs" - "students intimidating or bullying other students"
Teacher Behaviour (5 items)	0.802	- "teachers not meeting individual students' needs" - "teacher absenteeism" - "staff resisting change" - "teachers being too strict with students" - "teachers not being well-prepared for classes"

As part of PISA, scaling studies are carried out, and these studies are described in detail in the PISA Technical Report (OECD, 2017). Cronbach's alpha values have been calculated for each index to indicate the study's scale's internal consistency. A scale can be considered sufficiently reliable if Cronbach's Alpha is 0.7 or higher (Nunnally & Bernstein, 1991). Thus, it is considered that the high Cronbach alpha values in Table 1 and Table 2 are proof of the reliability of the PISA indices. Therefore, factor analysis was not done separately. Single items such as school truancy/skipping school (3 items) and gender were included in the analysis. Because more information can be associated with an index and the amount of measurement error is less for indices than single items, indices should be preferred to single items whenever possible (OECD, 2009). However, single-item measures included in the study are likely to suffice because of their simple (one-dimensional) and concrete constructs that are well understood. Such single items probably contain a small amount of measurement error. Nevertheless, using single items can be considered one of the weaknesses/limitations of this study.

The descriptive statistical values of students and school variables and correlations between these variables are given in Table 3 below. When Table 3 is examined, it is seen that almost all variables have a significant relationship ($p<.01$) with others at the student level. Additionally, there is a significant relationship ($p <.01$) between the variables, except the relationship between teacher behaviours hindering learning and the aggregated ESCS at the school level. This situation was interpreted as teacher behaviours not being affected by the average ESCS scores.

According to Table 3 above, both the disciplinary climate in science classes and teacher support in science classes are significantly negatively correlated with students' truancy, whereas ESCS is positively correlated with student's truancy. Besides, at the school level, a shortage of educational materials and a shortage of educational staff have a significantly positive relationship with the aggregated ESCS. Additionally, the study's descriptive statistics indicated a stronger significantly positive correlation between a shortage in educational materials, a shortage of educational staff, and student behaviours hindering learning.

Table 3. *Descriptive Statistics and Bivariate Correlations*

Student Level (n=5895)	M	SD	1	2	3	4	5
1. ESCS (Index of economic, social, and cultural status)	-1.45	1.66	1				
2. Teacher support in science classes	0.20	1.00	-0.06**	1			
3. Disciplinary climate in science classes	-0.13	0.96	-0.01	0.15**	1		
4. In the last two full weeks of school, how often: I<skipped> a whole school day	1.72	0.93	0.09**	-0.07**	-0.13**	1	
5. In the last two full weeks of school, how often: I<skipped> some classes	1.65	0.88	0.09**	-0.09**	-0.14**	0.58**	1
6. In the last two full weeks of school, how often: I arrived late for school	1.74	0.93	0.05**	-0.07**	-0.12**	0.35**	0.42**
School Level (n=187)							
1. Teacher behaviours hindering learning	0.13	0.89	1				
2. Student behaviours hindering learning	0.27	0.95	0.46**	1			
3. Shortage of educational materials	0.27	1.28	0.31**	0.35**	1		
4. Shortage of educational staff	0.62	1.15	0.32**	0.29**	0.49**	1	
5. Aggregated ESCS	-1.57	0.71	0.01	- 0.17*	-0.38**	-0.27**	1

**. Correlation significant at 0.01

Analytical Models

Since the PISA data was collected at both student and school levels, the dataset's structure was nested. For this type of dataset, using ordinary least squares regression for analysis would cause a loss of characteristic dependencies and increase the likelihood of Type I errors (Raudenbush, & Bryk, 2002). Therefore, HLM was used to model all data levels to overcome these limitations. HLM can analyse the relationships within and between different levels in data sets with a hierarchical structure. Therefore, it is more effective in calculating variance between variables at different levels than other analyses (Woltman, Feldstain, MacKay, & Rocchi, 2012).

HLM assessment was performed in three steps (considering the data's nested structure and preventing the errors listed above). In the first (fully unconditional) step, the variance was divided into its parts between school and in-school in science performances; this preliminary model is equal to a one-way ANOVA with random effects (Saed, & Hammouri, 2010). Intra-class correlation (ICC) was calculated as an indicator of inequality between the country's schools. Additionally, the reliability of the science performance score was estimated in this step. The second step was to produce a random (partially conditional) coefficient model to test the relationship between the student-level predictor factors and the outcome variable (science performance) and to determine the relative strength of the effects of the student-level variables (Woltman et al., 2012; Raudenbush, & Bryk, 2002). The third model (which is the model of fully conditional intercepts and slopes) examined whether students' average science performances within the same school was influenced by the level-2 factors and how much variance of science performances between schools could be explained by these factors.

Student-level predictors are generally group-centred variables to examine the effects of student-level and school-level variables independently. Centring at the school level, in most cases, is only necessary when other variables are needed to be controlling; as advised by Enders and Tofighi (2007), school-level predictors should be centred around the grand mean (Algina, & Swaminathan, 2011). In light of the aforementioned article, gender, skipping school, skipping some classes, arriving late to school, economic, social, and cultural status

(ESCS), teacher support, and disciplinary climate have been centred around the group mean. School resources (staff shortage and shortage of educational materials), school climate (teacher behaviours and student behaviours), and aggregated ESCS have been centred around the grand mean.

Fully Unconditional – Unconstrained Model

The aim here was to verify that the variability in the outcome variable was significantly different from zero at level 2 (school level); this enables determining whether there are variations in the outcome variable at the group level and whether HLM is required (Woltman et al., 2012). The following equations are used in the fully unconditional model:

Level 1 (student level):

$$Y_{ij} = \beta_{0j} + r_{ij}\ , Var(r_{ij}) = \sigma^2 = within - group\ variance\ in\ science\ performance.$$

Level 2 (school level):

$$\beta_{0j} = \gamma_{00} + u_{0j}\ , Var(u_{oj}) = \tau = between - group\ variance\ in\ science\ performance.$$

$\beta 0j$ indicates the mean of science performance in school j, and rij indicates the error variance for student i in school j for the student-level model. γ_{00} represents the grand mean science performance, and u_{0j} represents the random effect associated with school j for the school-level model (Raudenbush, & Bryk, 2002).

Random Intercepts Model (Partially Conditional)

The equations used for the partially conditional model are as follows:

Level 1 (student level):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Gender) + \beta_{2j}(Skipped\ whole\ day) + \beta_{3j}(Skipped\ some\ classes) + \beta_{4j}(arrived\ late) + \beta_{5j}(Disciplinary\ climate) + \beta_{6j}(Teacher\ support) + \beta_{7j}(ESCS) + r_{ij}, Var(r_{ij}) = \sigma^2.$$

Level 2 (school level):

$$\beta_{0j} = \gamma_{00} + u_{0j}\ , Var(u_{oj}) = \tau_{00};\ \beta_{1j} = \gamma_{10} + u_{1j}\ , Var(u_{1j}) = \tau_{11};\ \beta_{2j} = \gamma_{20} + u_{2j}\ , Var(u_{2j}) = \tau_{22};\ \beta_{3j} = \gamma_{30} + u_{3j}\ , Var(u_{3j}) = \tau_{33};\ \beta_{4j} = \gamma_{40} + u_{4j}\ , Var(u_{4j}) = \tau_{44};\ \beta_{5j} = \gamma_{50} + u_{5j}\ , Var(u_{5j}) = \tau_{55};\ \beta_{6j} = \gamma_{60} + u_{6j}\ , Var(u_{6j}) = \tau_{66};\ \beta_{7j} = \gamma_{70} + u_{7j}\ , Var(u_{7j}) = \tau_{77};$$

In the equations given above, σ^2 (in level 1) represents the student-level residual variance, and γ_{00} (in level 2) denotes the average school means of science performances among the 15-year-old students in the same school. The increment regarding school j is expressed as u_{0j} (in level 2). γ_{10} is the mean slope between gender and science performances, and the increment to the slope related to school j is represented by u_{1j}. γ_{20} (skipped a whole day), γ_{30} (skipped some class), and γ_{40} (arrived late for school) respectively represent the mean slopes between students' truancy and students' science performance. The increments to the slope related to school j are represented respectively as u_{2j}, u_{3j}, and u_{4j}. γ_{50} characterises the mean slopes between disciplinary climate and students' science performances, and the increment to the slope related to school j is represented by u_{5j}. γ_{60} characterises the mean slopes between teacher support and students' science performances, and the increment to the slope related to school j is represented by u_{6j}. γ_{70} characterises the mean slopes between ESCS and students' science performances, and the increment to the slope related to school j is represented by u_{7j} (Saed & Hammouri, 2010).

Fully conditional models (means-as-outcomes model)

The fully conditional model examined whether the level-2 factors affected students' average science performances within the same school and how much these factors could explain the variance in science performances among schools. Two models were considered to examine how Aggregated ESCS at the school level makes a difference. Thereby in model 1, shortage of educational materials, staff shortage, student behaviours, and teacher behaviours were included in the analysis; in addition to these variables, aggregated ESCS was also added to the analysis in Model 2. The equations used in these models were:

Model 1:

Level 1 (student level):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Gender) + \beta_{2j}(Skipped\ whole\ day) + \beta_{3j}(Skipped\ some\ classes) + \beta_{4j}(arrived\ late) + \beta_{5j}(Disciplinary\ climate) + \beta_{6j}(Teacher\ support) + \beta_{7j}(ESCS) + r_{ij}, Var(r_{ij}) = \sigma^2.$$

Level 2 (school level):

$$B_0 = \gamma_{00} + \gamma_{02}(Shortage\ of\ educ.material) + \gamma_{03}(Staff\ Shortage) + \gamma_{04}(Student\ behaviour) + \gamma_{05}(Teacher\ behaviour) + u_{0j}.$$

Model 2:

Level 1 (student level):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(Gender) + \beta_{2j}(Skipped\ whole\ day) + \beta_{3j}(Skipped\ some\ classes) + \beta_{4j}(arrived\ late) + \beta_{5j}(Disciplinary\ climate) + \beta_{6j}(Teacher\ support) + \beta_{7j}(ESCS) + r_{ij}, Var(r_{ij}) = \sigma^2.$$

Level 2 (school level):

$$B_0 = \gamma_{00} + \gamma_{01}(Aggregated\ ESCS) + \gamma_{02}(Shortage\ of\ educ.material) + \gamma_{03}(Staff\ Shortage) + \gamma_{04}(Student\ behaviour) + \gamma_{05}(Teacher\ behaviour) + u_{0j}.$$

3. Results

The analyses undertaken in this study aimed to determine the extent to which school-related factors could explain the variance in students' science performances and provide a detailed understanding of the effects of these differences on students' science performances. For this purpose, firstly, the unconditional model was applied to determine whether the dataset conformed to the hierarchical data analysis. The results of the fully unconditional model are shown in Table 4 below.

Table 4. *The Results of the Fully Unconditional Model for Science Performance*

γ00 (Grand mean)	409.64
Between-school variability (τ00)	3576.29
Within-School variability across all students (σ2)	2924.68
Intraclass correlation (ICC)	0.55

The results of the fully unconditional model showed that the school science performance mean (γ00) was 409.64. There was a significant variation between schools in terms of science performances. For example, the between-school variability in science was 3576.29, and the within-school variability was 2924.68. To determine the percentages of variance that could be attributed to the group and individual levels in science performances, ICC was calculated, and it was found that 55% (x^2(186) =7465.87, p<0,001) of the variance in science performances occurred at the group level. ICC's value, .25 or above, requires the application to HLM (Heinrich, & Lynn, 2001). Thereby, the results of the analysis supported the use of hierarchical linear modelling.

The partially conditional model was tested to determine the effect of the variables determined at the student level on the students' science performances. The results of this analysis are shown in Table 5 below. This model consisted of two demographic variables (ESCS and gender) and five individual behaviour variables (teacher support, disciplinary climate, and students' truancy). Beta coefficients indicated that only two of these seven student variables were significant predictors ($p<0.05$) of student performances.

Table 5. *The Effects of Student-level Variables on Students' Science Performance*

Fixed Effects	Coefficient (SE)	p-value
INTRCPT2, γ00	409,57 (5.55)	0.000
Gender, γ10	5.89 (2.24)	0.009
Number of times <skipped a whole day>, γ20	0.85 (1.36)	0.530
Number of times < skipped some classes>, γ30	-1.43 (1.25)	0.253
Number of times <arrived late for school>, γ40	1.25 (1.03)	0.224
Disciplinary climate, γ50	3.21 (1.34)	0.021
Teacher support to students, γ60	1.15 (1.19)	0.339
ESCS (economic social and cultural status), γ70	1.35 (0.88)	0.126
Random Effect	Var. Component	p-Value
INTRCPT1, U0	3584.92	0.000
Gender slope, U1	97.48	0.126
Number of times <skipped a whole day> slope, U2	34.11	0.024
Number of times < skipped some classes> slope, U3	17.89	>.500
Number of times <arrived late for school> slope, U4	14.64	0.388
Disciplinary climate slope, U5	23.92	0.276
Teacher support to students slope, U6	7.01	>.500
ESCS (economic social and cultural status) slope, U7	15.63	0.336
Level-1 effect rij	2806.54	

The results of the HLM analysis for the partial conditional model showed that, when the other variables at the student level were controlled, only gender (γ10=5.89, $p<0.05$) and disciplinary climate (γ50=3.21, $p<0.05$) were significantly related to student performances, which means that boys' performances in science were better than girls. Furthermore, students who reported a better disciplinary climate in their science lessons performed better in science. Students' truancy, teacher support, and ESCS were not significantly related to student's performances in science at the student level.

The fully conditional model was used to estimate the effects of school-level variables on students' science performances. The results are presented in Table 6 below. The results of the HLM analysis related to the second research question (Table 6) showed that teacher behaviours and a shortage in educational materials did not significantly affect science performances in Model 1 (respectively γ05=7.65 and p=0.140; γ02=-6.02 and p=0.094) and Model 2 (respectively γ05=-0.44 and p=0.926; γ02=1.60 and p=0.670). As expected in both models, staff shortage (respectively γ03=-13.85 and $p<0.001$; γ03=-7.71 and p=0.043) and student behaviours (respectively γ04=-19.74 and $p<0.001$; γ03=-15.74 and $p<0.001$) had a significant negative effect on science performances.

When the school ESCS score was included in the analysis, the shortage of education materials still did not significantly affect student performance variation. However, the coefficient value increased from -6.02 to 1.60. A similar change was observed in the variable of staff shortage, which declined to -13.85 from -7.71. This situation can be interpreted as follows - the variables of staff shortage and a shortage in educational materials implicitly contain ESCS-related variables and the school ESCS variable. When ESCS is calculated as an independent value and included in the analysis, the implicit ESCS effect was excluded from these variables, thereby revealing their contribution. However, as stated before, these two variables were not significant in both models. Similarly, teacher behaviours were not significant in both models; however, this variable's coefficient contributions decreased when the ESCS index was added. Student behaviours were significant in both models, and the coefficient of this variable changed when the school ESCS was included in the analysis.

Table.6. *Estimated Effects of the School-Level Variables on Students' Science Performance*

	Model 1		Model 2	
	Coefficient (SE)	p-value	Coefficient (SE)	p-value
INTRCPT2, γ00	409.87 (4.16)	0.000	414.09 (3.64)	<0.001
ESCS (Aggregated) γ01	-	-	49.98 (6.31)	<0.001
Shortage of educational material, γ02	-6.02 (3.57)	0.094	1.60 (3.76)	0.670
Staff shortage, γ03	-13.85 (4.12)	0.001	-7.71 (3.79)	0.043
Student behaviour, γ04	-19.74 (4.93)	0.000	-15.74 (4.21)	<0.001
Teacher behaviour, γ05	7.65 (5.16)	0.140	-0.44 (4.76)	0.926
	Model 1		Model 2	
Random Effect	Var. component	p-value	Var. component	p-value
INTRCPT1, U0	2694.10	0.000	1508.86	<0.001
Gender slope, U1	98.36	0.126	107.36	0.089
Number of times <skipped a whole day> slope, U2	34.04	0.024	34.32	0.028
Number of times < skipped some classes> slope, U3	17.93	>.500	24.80	>0.500
Number of times <arrived late for school> slope, U4	16.42	0.386	18.49	0.393
Disciplinary climate slope, U5	24.44	0.273	25.60	0.245
Teacher support to students slope, U6	6.46	>.500	7.80	>0.500
ESCS (economic social and cultural status) slope, U7	15.43	0.348	15.83	0.461
level-1 effect rij	2807.46		2767.13	

4. Discussion

This research aimed to determine how students' science performances are affected by school-related and student-related factors in Turkey, and when the school ESCS is calculated and determined as an independent variable, how students' science performances are affected by school-related factors. According to the results, in terms of gender variation (one of the significant variables at the student level), it was determined that boys' science performances were better than girls in both models. The examination of previous PISA studies results revealed clear differences between male and female students (OECD, 2004, 2016b). González de San Román and de La Rica (2016) investigated the differences between male and female students to demonstrate the effects of gender inequality and gender roles. The results were in favour of the male students. Another significant variable that influences science performances at the student level is the disciplinary climate. In all countries and economies (except Argentina and Korea), students have better science performances in science lessons conducted in a better disciplinary climate (OECD, 2016). However, when the school aggregated ESCS score is examined (Model 2), the disciplinary climate variable was not significant in science performances. This finding suggests a relationship between teachers' classroom management skills and the ESCS levels of school and students. This has two possible reasons; (1) teachers in the low ESCS group may be less attentive to the students and less willing to engage in classroom management, and (2) the proportion of teachers with competent classroom management skills is low in schools with a low ESCS index. However, only qualitative research can help better understand the underlying cause or causes of this situation.

Other variables at the student level (students skipping school, teacher support, and ESCS) were not significantly related to students' science performances in either model. As stated above, Turkey's current examination system is test-oriented, which leads most students to seek extracurricular courses, private tutoring, and academic support. This may be why these three variables were not significantly related to students' performances in science. On the other hand, in the literature, some researchers have suggested that the results of skipping school can lead to additional problems other than low academic success. The frequent absence from school may be associated with working in low-paid jobs, unwanted pregnancy, drug and alcohol use, and attempting suicide (Baker, Sigmon, & Nugent 2001; Barber, Stone, & Eccles 2010; Hallfors, Cho, Brodish, Flewelling, & Khatapoush, 2006; Henry, & Huizinga, 2007; Juvonen, Espinoza, & Knifsend, 2012; Valeski, & Stipek, 2001). Therefore, the high rate of school truancy in Turkey than other OECD countries must be investigated.

The fact that ESCS is less than -1 at both the student and school levels shows that most 15-year-old students are disadvantaged in Turkey. Disadvantaged students were reported as 69% in PISA 2012; this rate was reported as having decreased to 64% for PISA 2015. Although there is a worthy decrease in the percentage of disadvantaged students in time (69% in PISA 2012; and 64% in PISA 2015), the proportion is still considerably high. Disadvantaged students tend to have lower science scores in PISA and require more teacher support (OECD, 2016). To make the most of learning opportunities, students need the school staff's support, especially teachers (Klem & Connell 2004). Students, including those with disadvantages, develop more positive attitudes and are better motivated when provided with attention and support from their teachers (Skinner, Pitzer, & Steele, 2016; Ricard, & Pelletier, 2016). Despite the positive relationship between ESCS and truancy, the negative relationship between ESCS and teacher support, and the negative relationship between truancy and teacher support, it was determined that these variables were not significant predictors of student performances in either model. One of the possible explanations for this situation is that, as mentioned above, students in Turkey usually seek additional educational support outside school.

When the aggregated ESCS was controlled, it is observed that the school-level variables had a higher effect on students' science performances. As expected, staff shortage and student behaviours negatively affected students' science performances in both models. Especially in Model 2, where the ESCS variable at the school level was controlled, these variables' effect on science performances was reduced. When the quality and quantity of resources decrease, school conditions deteriorate; it is well-known that poor school conditions have reduced students' academic success (OECD, 2016). In this study, however, there was no significant relationship between the shortage of educational materials and students' science performances. Student-related problems reported by the school principal (such as truancy or bullying) are more clearly related to science performances than teacher-related problems (such as teacher absenteeism or staff resisting change). Therefore, it is better to have a teacher in the classroom than having no teacher, even if the teacher occasionally misses classes or is not well prepared for class. In education systems with small differences between schools, students are not classified based on need or ability. Differences between schools are inevitably more evident in education systems that attempt to meet the students' different needs and guide students to make career-related decisions at an early age. Therefore, these systems tend to produce different outputs with varied training programs and approaches. This study's sample consisted of students from Turkey, a country in which the education system is test-oriented and has high school diversity with different curriculums; thus, there were considerable differences in students' performances in science (ICC=55%). Considering the impact of social effects such as school quality on students 'academic achievements (Baker, et al., 2002), it can be stated that school diversity is one of the main reasons for the differentiation of students' science performances.

A higher intra-class correlation means greater between-school variation. Turkey has one of the highest between-school variations in OECD countries; this finding shows that Turkey's schools are very differentiated in gaining science skills. In this case, the quality and equity in science education are not sufficient due to lower science performance and high school diversity. There is a broad range of ICC values across countries, from less than 10% for schools in Iceland, Finland, and Norway to 55-60% for the schools in the Netherlands, Hungary, and Turkey (OECD, 2017). School diversity with different curricula is shown as one of the causes of the high variation in student performances between schools (Berberoğlu, Çalışkan, & Karslı, 2019; Agasisti, Avvisati, Borgonovi, & Longobardi, 2018; Authors, 2013).

Science teachers should create conducive learning environments for better student understandings. One of the requirements for creating a conducive learning environment is having fewer disciplinary problems and more teacher support in science lessons (Ma, & Willms, 2004). Descriptive statistics at the student level showed that students' truancy was less under the circumstances perceiving teachers' support more and in a better disciplinary climate. Additionally, findings suggest a significant correlation between a shortage of educational materials, a shortage of educational staff, and students' behaviours hindering learning. Hence, further research could investigate the effect of the improvements in the shortage of educational materials and the shortage of educational staff on students' behaviours hindering learning.

5. Conclusion and Recommendations

Findings obtained within this research scope reveal that ESCS is one of the most important variables in determining student performances, whether at the student or school level. In addition to this finding, it was understood that school-based factors such as lack of staff and lack of educational materials were indirectly affected by the school ESCS variable as expected. In this research, we found that a teacher's classroom presence positively influences student performances, although it is not well-prepared. PISA emphasised that students who report a better classroom environment in science classes perform better in science (OECD, 2016). When all these findings are interpreted with school ESCS findings, the school ESCS variable's effect on student performances becomes clearer. Although it is not possible to improve schools 'ESCS indexes under these conditions in a short time, it can be seen that students' science performances can be improved by eliminating the lack of educational materials or staff because the schools differ greatly in terms of sociocultural structure, unlike other OECD countries. In this case, both low science performances and performance differences between school types make it difficult to ensure equality of quality and opportunity in science education. According to Yıldırım (2012), the effect of ESCS decreases as the effect of school-related variables and classroom climate variables on student performances increases. However, he emphasised that Turkey's quality of teaching practices is not good enough to reduce the performance differences caused by ESCS. Therefore, it may be possible to overcome these differences with education reforms in the long term. Still, the finding that students' science performance can be improved by eliminating the lack of educational materials and teacher shortages in the short term is one of the most concrete outcomes of this research. It is recommended to carry out studies focusing on revealing the relationship between student performances between schools in the same school type and school ESCS.

Limitations of the Study

This study has some limitations, and the results should be considered under these limitations. Firstly, since PISA is a cross-sectional and observational study, the findings cannot be considered as causal assertions. Secondly, the findings are valid only for 15-year-old students attending schools. Thirdly, there is a limitation to how students are measured; for example, the measure of participation is not always a truancy measure, since some students may have not been able to attend school because of illness or other accepted excuses. Thus, the measure of participation should be considered as a measure of absenteeism. However, in this study, "school truancy" is consistent with PISA's conceptual framework. Finally, even though the detailed statistical techniques are used to control the limitation of the usage of plausible value for students' science performances, using the plausible values as a dependent variable can also be seen as another limitation of the study.

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