EXPLORING THE PSYCHOLOGICAL NEEDS AND SCHOOL ATTACHMENT AMONG MIDDLE SCHOOL STUDENTS: A TIMSS 2019 ANALYSIS

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Abstract

This study utilizes the TIMSS 2019 dataset to scrutinize the scho engagement of 8th-grade students within the Turkish education syste Employing the Random Forest method, a data mining technique, v investigate factors in science and mathematics domains that a theorized to influence school engagement. The research delves i psychological elements, including lesson preferences, confidence science, self-assurance, absenteeism, and the impact of teache instructional methods on school engagement, with a specific focus student bullying. The sample comprises 3872 students in the scien dataset and 3802 students in the mathematics dataset, resulting fro data deletion and assignment processes from the original 40 participants. Analysis utilized the open-source Python infrastructu with the Orange 3.32 data mining program facilitating model setu Evaluation metrics such as MSE, RMSE, MAE, and R2 values we employed to assess model performance. Results reveal commendab model performance, with values approximating zero in both scien (MSE: 2.775, RMSE: 1.666, MAE: 1.267) and mathematics (MS 2.240, RMSE: 1.497, MAE: 1.131) domains. Variables accounted f 69.6% of school engagement in science and 75.7% in mathematics. T order of importance of variables exhibited substantial similarities both areas, with student bullying identified as the most crucial facto Our findings underscore the significance of addressing student bullyi to enhance school engagement, emphasizing the psychological nee and attachment of middle school students. Future research endeavo should employ qualitative data collection methods, consideri perspectives from students, peers, teachers, and parents. V recommend that education policies, particularly those crafted by t Turkish Ministry of National Education, prioritize sustained efforts reduce and prevent student bullying in schools. School administratio

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supported by counselors, should focus on diagnosing and mitigating bullying-related issues within and outside the school environment.

Introduction

Educational systems universally aspire to produce well-rounded individuals capable of academic excellence and fostering positive social relationships. The fundamental premise is that students should harbor a genuine affection for school, as it plays a pivotal role in achieving educational objectives. School engagement (SE) is posited as a key driver, influencing both academic success and social interaction positively. Research consistently supports the view that SE correlates with enhanced academic performance and improved learning skills (Ladd & Dinella, 2009). Additionally, high SE is linked to positive social relationships and increased social competencies among students (Demirtas-Zorbaz et al., 2018).

While student-related factors may contribute to a lack of enthusiasm for school, external factors such as family, peer influences, and the school environment are equally significant contributors to SE (Fernández-Zabala et al., 2016). Understanding SE as a multi-faceted construct underscores its importance to all stakeholders in education. This complexity is also evident in the Turkish education system (TES), where research indicates the need to explore SE with various variables. Recognizing that schools are crucial for healthy child development, it becomes imperative to identify factors promoting students' commitment to school.

The symbiotic relationship between SE and academic success is highlighted in studies such as Kaya and Boyraz's (2020) meta-analysis, which reveals a weak positive effect of SE on academic achievement. Further studies by Özdemir and Yalçın (2009) and Altuntaş and Sezer (2017) establish positive correlations between SE levels and academic scores in various subjects. Considering these findings, SE emerges as a linchpin in the holistic development of students.

This research focuses on elucidating the variables influencing science and mathematics scores of 8th-grade students in TES, using the TIMSS 2019 Turkey data. By employing the Random Forest (RF) method, the study aims to analyze the impact of these variables on SE.

SE, as the most comprehensive meta-structure, encompasses behavioral, emotional, and cognitive engagement (Fredricks et al., 2004; Jimerson et al., 2003; Li et al., 2020). Li, Gao, and Sha (2020) define SE as students' engagement in learning activities and the intensity of their emotions during these processes. Cognitive school engagement involves intellectual progress related to classroom challenges and learning goals (Ay, 2022). These dimensions collectively represent observable outward expressions and emotional reactions, integral to understanding a learner's engagement.

For a school to foster increased SE and reduced dropout rates, it should possess attractive features and cultivate positive relationships among students and educators. Notably, the study by Kukuş and Akto (2022) emphasizes students' preference for schools with positive atmospheres, supportive teacher-student relationships, and physical amenities. Similar findings in TES underscore the importance of positive familial relationships and friendships in bolstering students' commitment to school (Özbilen, Eranıl, & Özcan, 2018).

In TES, SE is not without challenges. Arastaman (2009) suggests that students' commitment to school may be exam-oriented, and a decline in commitment with increasing grade levels is noted (Şahan & Özgenel, 2021). Furthermore, transportation considerations and academic performance influence SE, particularly in vocational high schools, where students may face additional socioeconomic challenges. Notably, the literature reveals a negative correlation between SE, deviant behaviors, and substance use in TES (Ünal & Çukur, 2011).

TIMSS 2019 data is instrumental in understanding the commitment of 8th-grade students to school in TES. While some studies explore SE, none comprehensively investigate it in the Turkish education system using

the RF method within the realm of educational data mining. This research addresses this gap by focusing on the variables explaining SE and its relationship with mathematics and science achievement scores.

2. Methodology

2.1. Research Model

This quantitative study employs a correlation survey model, aiming to establish associations between variables in a large group. It emphasizes correlational and regression approaches to understand relationships between predicted and predictor variables.

2.2. Study Group

The study involves 4,077 Turkish students from the TIMSS 2019 application, with missing demographic data rectified through exclusion. Data analysis focuses on science and mathematics, with 3872 students in the science dataset and 3802 students in the mathematics dataset.

2.3. Data Collection Tools and Procedure

The TIMSS 2019 application includes cognitive and affective scales in science and mathematics. Variables related to SE were investigated using the 'Random Forest' data mining method. Expert opinions were considered in selecting variables, and exploratory factor analysis validated scale reliability.

2.4. Data Analysis

Multicollinearity tests, using Variance Inflation Factor (VIF) and Tolerance values, indicated no issues among variables. The 'Random Forest' method, a non-parametric approach, was chosen for analysis, considering the non-parametric nature of the dataset. Model performance metrics such as Mean Squared Error (MSE), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Coefficient of Determination (R2) were employed to assess the model's accuracy.

2.5. Ethical

The research received approval from the Van Yüzüncü Yıl University Ethics Commission, ensuring compliance with ethical standards.

3. Findings

In this section, the findings obtained in terms of metric values are shared in order, first for the science field and then for the mathematics field.

Science Score and SE: For the model established in the field of science, the most suitable number of trees to form the decision forest has been determined. The analysis of tree numbers was repeated for each selection as 100, 250, 500, 750, 1000, 1500, 2000, and 3000. The results obtained are presented in Table 1.

Table 1. *Determination of the Maximum Sufficient Number of Trees According to the Metrics Obtained in Science*

Field	Number of trees	MSE	RMSE	MAE	R^2
Science	100	2.811 2.790 2.787	1.676 1.670 1.670	1.273	1.272 0.692
	250	2.775	1.666	1.270 1.267	0.695
	500	2.776	1.668	1.269	0.695
	750				0.696
	1000				0.696
	1500	2.776	1.666	1.267	0.696
	2000	2.776	1.667	1.268	0.696
	3000	2.778	1.667	1.268	0.696

As can be seen in Table 1, the lowest error value was obtained for the number of 750 trees. In all subsequent tree numbers, it was observed that the error rate was always the same or close to it. It can be said that the same

or close values are obtained no matter how much the number of trees increases. The analysis results obtained for the model established in this study were obtained with a total of 750 trees.

The MSE value is 2.775, the RMSE value is 1.666, the MAE value is 1.267, and R^2 was obtained as 0.696. Evidently, the MSE, RMSE, and MAE values are close to zero. The fact that these values are zero means that the established model does not have any mistakes. In this direction, the obtained values indicate that the error rate is low. It can be said that the values estimated by the method are close to the real values. The percentile of the coefficient of determination reveals the explained variance of the model. In this study, it was realized that the independent variables included in the model explain 69.6% of the dependent variable. The most important predictors and significance levels of these variables on the dependent variable in the established model are given in Table 2.

Table 2. *Significance Levels of Variables in Science According to the Random Forest Method*

	Variables	Data type	Severity level	%
1	Student bullying	Continuous	0.232	23,3
2	Students value science	Continuous	0.162	16,2
3	Students like learning science	Continuous	0.161	16,1
4	Instructional clarity in science lessons	Continuous	0.155	15,5
5	Student confident in science	Continuous	0.145	14,5
6	Absenteeism	Categorical (5)	0.023	2,3
7	Intended graduation level in education	Categorical (6)	0.018	1,8

Categorical 5: "Hardly ever" Categorical 6: "Postgraduate"

When Table 2 is viewed, the most important predictors of SE are: student bullying, student values of science, students like learning science, instructional clarity in science lessons, student confidence in science, absenteeism, and intended graduation level in education. The scatter plots showing the relationship between the variables that are continuous among the independent variables and SE are presented in Figure 1.
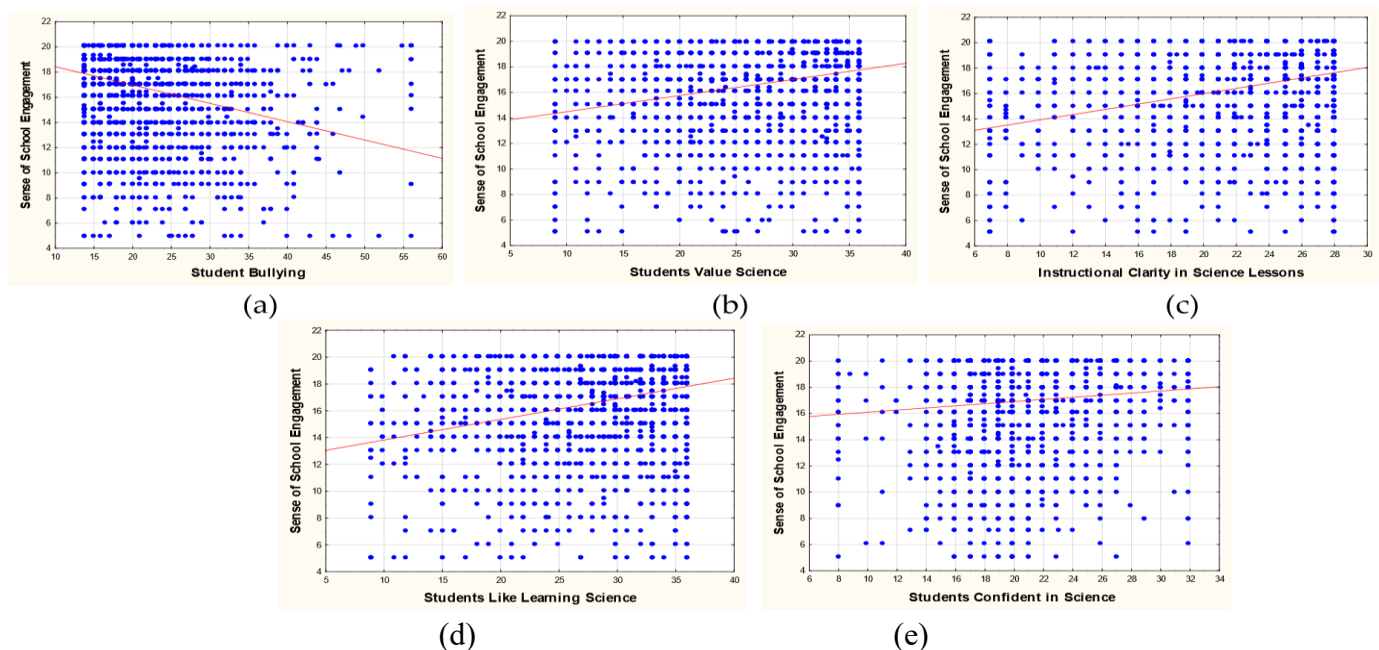

(a)　　　　(b)　　　　(c)

(d)　　　　(e)

Figure 1. *Scatter Plots Displaying the Relationships Between the İndependent Variables in Science and the Dependent Variable (SE)*

As can be seen in Figure 1a, there is a negative relationship between student bullying and SE. SE decreases as long as student bullying increases. In Figure 1b, SE increases as student values of science increase. In Figure 1c, the SE increases as the instructional clarity in science lessons increases. Similarly, SE increases as

students like learning science increase (Figure 1d). Finally, the SE increases as student confidence in science increases, albeit at a low level.

Mathematic Score and SE: For the model established in the field of mathematics, the most appropriate number of trees has been determined to create the decision forest. In this frame, the analyses were repeated for each selection, with tree numbers of 100, 250, 500, 750, 1000, 1500, 2000, and 3000. The results reached are presented in Table 3.

As can be accessed through Table 3, the lowest error value was obtained at the number of 1000 trees. In all subsequent tree numbers, it was unearthed that the error rate was always the same or close to it. This can be accounted for by the fact that the same or close values are obtained no matter how much the number of trees rises. The analysis results obtained for the model established in this study were obtained with a number of 1000 trees.

Table 3. *Determination of the Maximum Sufficient Number of Trees According to the Metrics Obtained in the Field of Mathematics*

Field	Number of trees	MSE	RMSE	MAE	R^2
Mathematics	100	2.300 2.251 2.266	1.517	1.500 1.143	1.135 0.750
	250	2.250 2.240	1.505	1.500 1.136	1.132 0.756
	500	2.240	1.497	1.131	0.754
	750		1.500	1.133	0.756
	1000				0.757
	1500				0.756
	2000	2.241	1.497	1.131	0.757
	3000	2.242	1.499	1.132	0.756

The MSE value is 2.240, the RMSE value is 1.497, the MAE value is 1.131, and R^2 was obtained as 0.757. It is noticed that the MSE, RMSE, and MAE values are close to zero, so one may say that the obtained values have a low error rate. As a result, the model verifies that the values estimated by the method are close to the true values. On top of these, it is contemplated that the independent variables included in the model explain 75.7% of the dependent variable. The most important predictors and significance levels of these variables on the dependent variable in the established model are communicated in Table 4.

Table 4. *Significance levels of variables in the field of mathematics according to the random forest method*

	Variables	Data type	Severity level	%
1	Student bullying	Continuous	0.173	17,3
2	Instructional clarity in math lessons	Continuous	0.170	17,0
3	Students like learning mathematics	Continuous	0.166	16,6
4	Students value mathematics	Continuous	0.127	12,7
5	Student confident in mathematics	Continuous	0.123	12,3
6	Disorderly behavior during mathematics lessons	Continuous	0.118	11,8
7	Absenteeism	Categorical (5)	0.018	1,8
8	Intended graduation level in education	Categorical (6)	0.015	1,5

When Table 4 is scanned, the essential predictors of SE are, respectively, flows: student bullying, instructional clarity in mathematic lessons, students like learning mathematics, students value mathematics, students are confident in mathematics, disorderly behavior during lessons, absenteeism, and intended graduation level in education are variables. Figure 2 illustrates the scatter plots showing the relationships between the continuous variables, which are independent variables, and the SE.
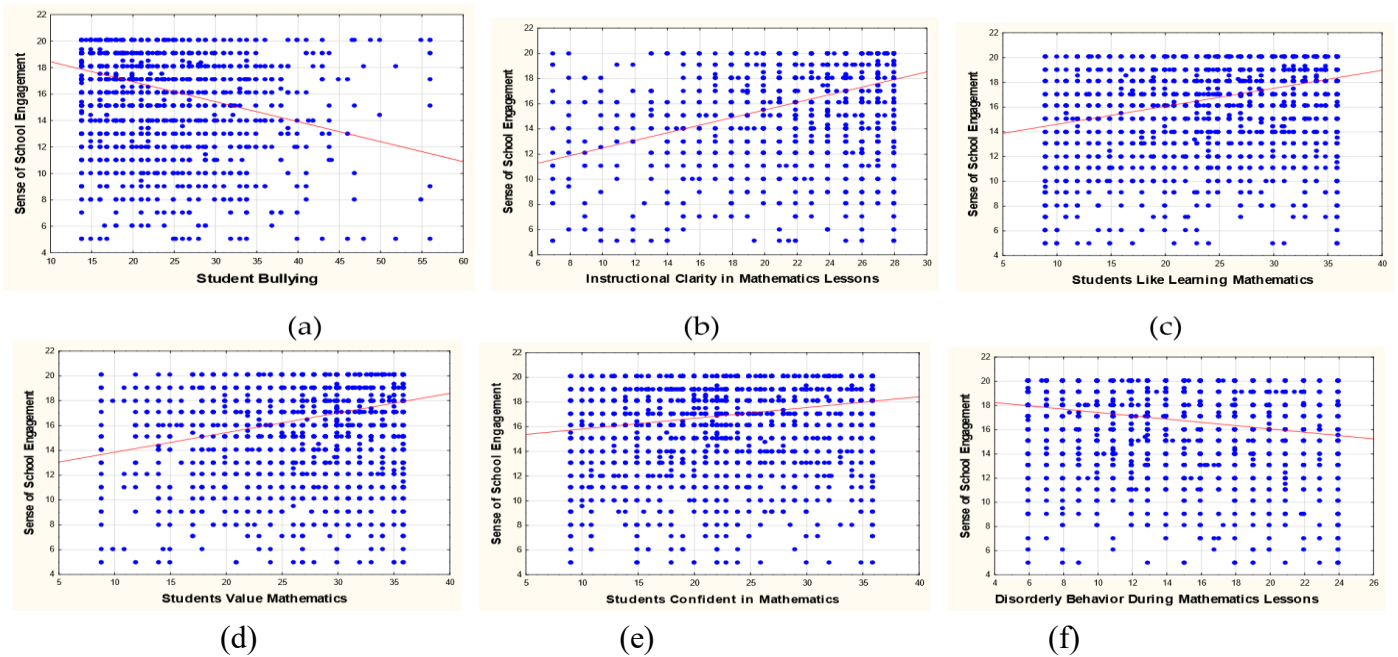
Figure 2. *Scatter Plots Showing the Relationships Between Independent Variables in Mathematics and the Dependent Variable (SE)*

Figure 2a demonstrates a negative correlation between School Engagement (SE) and student bullying; as bullying increases, SE decreases. Conversely, Figure 2b indicates that SE rises with enhanced instructional clarity in math lessons. Figure 2c reflects an increase in students' liking for learning mathematics as SE multiplies. Similarly, in Figure 2d, SE amplifies as students' mathematical value progresses. Notably, a slight increase in SE is observed in students confident in mathematics. Conversely, a negative relationship exists between disorderly behavior during mathematics lessons and SE, with SE decreasing as disorderly behavior increases.

2. Conclusion and Discussion

This study examines the SE of 8th-grade students in Turkey participating in TIMSS 2019, employing the Random Forest method to analyze variables in science and mathematics. Each variable significantly contributes to predicting students' commitment to school. Student bullying emerges as the most influential variable, with its reduction significantly enhancing SE. SE is a complex process influenced by various factors, including the school environment, friend and teacher relations, and family structure. Family support is crucial for students' SE.

Studies emphasize the importance of developing students' SE against peer bullying, as it is linked to negative consequences such as school dropout. Students who feel unsafe or uncomfortable due to bullying show degraded commitment to school. Positive perceptions of school safety correlate with higher scores in Turkish, mathematics, and science. Bullying leads to negative emotions and harmful behaviors, impacting students' SE and academic development.

Friendship and peer support significantly contribute to SE, while teacher and peer bullying influence student behavior. Lowering peer bullying positively impacts students' commitment to school, fostering academic development. Additionally, a positive relationship exists between SE and students' academic desire and development.

3. Impact of Lesson Engagement on SE

The study identifies 'student values lesson' as second in science and fourth in mathematics, strengthening SE. 'Students like learning lessons' ranks third in both fields, correlating positively with SE. Students' love for

science and mathematics predicts SE, emphasizing the importance of liking and valuing lessons. Positive perceptions of the school environment, teacher trust, and emotional commitment to school contribute to SE.

4. Variables Contributing to SE Prediction

'Instructional clarity in lessons' ranks fourth in science and second in mathematics among variables predicting SE. 'Student confident' ranks fifth in both fields. In the mathematics field, 'disorderly behavior during mathematics lessons' is ranked sixth in importance, indicating its negative impact on SE.

5. Suggestions

The study suggests prospective qualitative research to collect more in-depth data, incorporating diverse perspectives. Recommendations include sustainable anti-bullying practices, curriculum alignment with students' interests, and professional development for teachers. Holistic measures addressing individual and systemic factors are essential for enhancing SE.

Limitation of the Research

The study is limited to TIMSS Turkey 2019 data for 8th-grade students.

Disclosure Statement and Conflict of Interest

The research received no specific grants, and there is no conflict of interest between the authors, both of whom contributed equally to the article.

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