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Absenteeism, Self-Confidence and Academic Performance: Empirical Comparison of Turkey and Singapore

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Abstract: In today's World, data-driven methods are behind the determination of potential action plans in every area of life. These data-driven methods help individuals or policymakers to figure out the strengths and weaknesses on the subject that are worked on and to make a comparison to the best practices. Thus, actions can be taken immediately on the specific factors that have a huge impact on the topic investigated. In the educational area, countries are using the same approach to measure, monitor, and improve the quality of education by attending international studies. In this study, for both Turkish and Singaporean students, Artificial Neural Network (ANN) model is performed to predict the students' mathematics achievement and to identify factors that have a high impact on achievement using Trends in International Mathematics and Science Study (TIMSS) in 2019 with the data of 3,586 Turkish and 4,750 Singaporean students. The reason behind comparing the results of Turkey to Singapore is that Singapore is the best-performing country in terms of mathematics achievement in the TIMSS in 2019. The model results show that the top two crucial factors in both countries are the frequency of absenteeism from school, and students' confidence in mathematics with the accuracy of 75%. In addition, relevant policy implications are given based on the importance level of significant factors.

Keywords: *Absenteeism from school, confidence in mathematics, mathematics achievement, neural networks.*

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Introduction

The ability of data-driven thinking, which is a phenomenon that exists in every moment of our daily lives, has a crucial role to reach a high level of academic and social status for a country. Thus, it is needed to measure the level of achievement from a global perspective for a country to determine its position at the international level. This basic need encourages countries to attend many studies aimed to measure mathematics, science, and reading literacies at the international level that have been performed by different international organizations in the last 20 years. The Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS), and the Progress in International Reading Literacy Study (PIRLS) can be given as international studies aimed to measure country-based mathematics, science, and reading literacies from the data-driven thinking point of view. Furthermore, the results of these studies can help policy-makers to create action plans about how the level of achievement is improved. These action plans are also directly or indirectly related to not only social but also economic problems such as child marriage, child labor, dropping out of school, and poverty. In addition, other positive impacts of improving mathematics, science, and reading literacy are that people can know their social rights, implement the Stop, Hone, Accumulate, Reason, and Perspectivize (SHARP) thinking methodology into their daily life, and gain an ability to see things from a different perspective (Kılıç Depren & Depren, 2021; Reboot Foundation, 2021). That is why countries are attending these studies to measure, monitor, and improve their achievement level at the international large-scale assessments.

Amongst the extant literature conducted in this field, many studies are examined to determine factors affecting students' achievement. Students' achievement differences between boys and girls, socioeconomic status of the family, and parental support are frequently examined in the literature with different approaches such as t-test, linear regression, or quantile regression approaches (Contini et al., 2017; Ding & Homer, 2020; Sánchez et al., 2019). Students' background factors, learning methods, and students' attitudes on mathematics or school environment are the other

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significant factors affecting students' achievement in the literature as well (Abu Saa et al., 2019; Sheldrake et al., 2017). In addition, it is known that a better school environment, small school size, and high environmental awareness have a positive impact on students' achievement (Giambona & Porcu, 2018; Kılıç Depren, 2020). Furthermore, students' tendency to attend school is thought as an important factor affecting students' achievement positively (Duke, 2020; Sekiwu et al., 2020). Once the attendance is high, students' achievement will be higher than the average score of the students. Not only the school environment but also educational resources at home are also significant factors to improve students' achievement. Gómez-Fernández and Mediavilla (2021) and Saal et al. (2021) show that the use of the internet and communication technologies at home has a positive impact on students' achievement while Kılıç Depren (2020) and Kılıç Depren and Depren (2021) revealed that students who have their study room at home are outperforming others. In the literature, one of the most studied topics is attitude and anxiety in mathematics (Wang et al., 2020; Zakaria et al., 2012). These studies suggest that mathematics anxiety harms students' achievement while a positive attitude in mathematics has a great positive impact on students' mathematics achievement.

In this research, a deep learning approach, which is named artificial neural networks (ANN), is performed rather than classical multivariate statistical analyses to determine the most important factors affecting the mathematics achievement of both Turkish and Singaporean eighth-grade students in TIMSS studies. The significant contributions of the study in the literature are that (i) ANN approach, which is not frequently used in the extant literature of educational area, is performed as a robust algorithm to contribute the literature from a different perspective, (ii) the most up-to-date data of TIMSS study is analyzed to evaluate the results, and (iii) since Singapore is the best-performing country in TIMSS 2019 study, this research can lead Turkish policy-makers to settle up action plans via comparing the actions taken on most important factors in Singapore.

The Problem of Research

The mathematics achievement level of Turkish 8th-grade students measured by the TIMSS 2019 study shows that the score of Turkey (496) was relatively lower than the TIMSS scale center point (500). Although Turkish students' mathematics scores increased from 458 in TIMSS 2015 study to 496, there is still room for improvement for that country. The best way for the improvement is to take the best performer country (Singapore in TIMSS 2019) into consideration in terms of the school curriculum, the quality of teachers, teaching methods, education policy, and resources. These factors should be customized by students' technical and social abilities, interests, and awareness just like in Singapore rather than applying too general actions performed to all students in Turkey (Oyvat & Tekgüç, 2019). These actions probably take too long to be implemented in the current curriculum but some no-cost-actions about students' working place at home, school attending, or family emotional support can be taken immediately.

Besides, Singapore has reached outstanding success in TIMSS 2019. With this point of view, Turkey should take the education policy of Singapore as a reference to improve the educational level of Turkey in the global area. Also, a comparison of factors affecting students' achievement between Turkey and Singapore can be a starting point to reach the level of applying theoretical knowledge to real-life problems for students.

In light of this information, the problem of this research is how to find out a concrete solution to both two questions; (a)What are the factors affecting students' academic achievement?; (b) How can they be improved properly?

Research Focus

With this research, the main factors of the students towards achievement in Turkey and Singapore are investigated to answer the following questions:

1. What are the main factors affecting students' mathematics achievement in Turkey and Singapore?
2. In terms of mathematics achievement, is the level of importance of these factors differentiated between Turkey and Singapore?
3. Once Singapore is taken as a reference point, which precautions should be taken to improve the level of mathematics achievement in Turkey?

Methodology

Dataset and Sampling

The study uses data from the International Association for the Evaluation of Educational Achievement's (IEA) TIMSS study 2019, which has been conducted every four years since 1995 and rawdata is shared to public. In TIMSS, 46 countries in the 8th-grade assessment that each involve approximately 220 questionnaire items for science and mathematics participated. The two-stage random sampling design was employed in TIMSS, the first stage by selecting the schools in the sampling frame, and then students drawn from each of the sampled schools as a second stage. For the first stage, schools are sampled with probability proportional to their size (PPS) from the sampling frame in the population. The second stage comprises drawing one (or more) class from each participating school. All students in each sampled class participate in the TIMSS study (Martin et al., 2020).

The sample of this study consists of mathematics achievement and student questionnaire items in schools located in Turkey and Singapore. Excluding the missing values, 3,840 Turkish students (out of 4,077 students) and 4,777 Singaporean students (out of 4,853 students) were used in this analysis. The indexed variables obtained by Item Response Theory (IRT) are shown in Table 1 with the IDX suffix.

Table 1. TIMSS Question Codes and Descriptions of Variables Used in the Study

Variable Name	Description
BSMMAT01	Mathematics achievement, which is the dependent variable, is flagged as 1 if the achievement is higher than the country's average, 0 otherwise
BSBG01	Gender
BSBG10	About how often absent from school
BSDG05S	Number of Home Study Supports (IDX)
BSBGHER	Home Educational Resources (IDX)
BSBGSSB	Students Sense of School Belonging (IDX)
BSBGSB	Student Bullying (IDX)
BSBGSLM	Students Like Learning Mathematics Lessons (IDX)
BSBGICM	Instructional Clarity in Mathematics Lessons (IDX)
BSBGDML	Disorderly Behavior during Math Lessons (IDX)
BSBGSCM	Student Confident in Mathematics (IDX)
BSBGSVM	Students Value Mathematics (IDX)
BSBGSEC	Self-Efficacy for Computer Use (IDX)

In Table 1, gender, how often absent from school, and the number of study supports are defined as categorical; the other variables are defined as index variables. When analyzing mathematics achievement by country's average, students from Turkey (Mean=496) performed lower than students from Singapore (Mean=616).

Instrument and Procedures

Machine learning approaches are based on statistical analysis to learn from data and predict a model. They become alternatives to traditional methods when the dataset is large and heterogeneous. Machine learning can provide accurate results by developing efficient algorithms. Many regression and classification methods are intrinsically nonlinear trends in the data. When performing these models, the nonlinearity form can adapt to the most popular machine learning algorithms such as k-nearest neighbors (k-NN), logistic regression (LR), multivariate adaptive regression splines (MARS), and neural networks (NN), before model training.

NN is utilized as a structure for the way a human brain deals with extremely complicated patterns. NN has robust nonlinear relationships in real-time data processing that can solve these patterns by modeling neurons in the brain (Titterington, 2010). This method can be created from three or more layers: an input layer, hidden layer(s), and an output layer. Firstly, the observed data is taken to the input layer. Then the hidden layer in NN can identify nonlinear relationships by using an iterative approach to make predictions. Finally, the model with the highest value of weight decay is selected.

In NN for classification, the dummy variables for each class (C) can be used as the outcomes (named as dependent or response variable). Each class has multiple hidden variables (or units) that are the combinations of the independent variables. The combinations can be transformed by a nonlinear function (usually by a sigmoidal) in the model. The softmax transformation must be used to force the predicted values into probability-like values. The class probability estimates and transformation are defined as

$$h_{ij}^{*}(x) = \frac{e^{h_{ij}(x)}}{\sum_j e^{h_{ij}(x)}} \quad (1)$$

$$\sum_{j=1}^{C}\sum_{i=1}^{n}\left(y_{ii} - h_{ij}^{*}(x)\right)^2 \quad (2)$$

$h_{ij}(x)$ is predicted of the j_{th} class and the i_{th} sample, y_{ij} is the dummy indicator (0/1). Thus, the predicted values of class membership are within 0 and 1 for identifying parameter values. To classify the sample, the class with the largest predicted value could be used (Kuhn & Johnson, 2013). Figure 1 depicts the structure of the NN for classification.

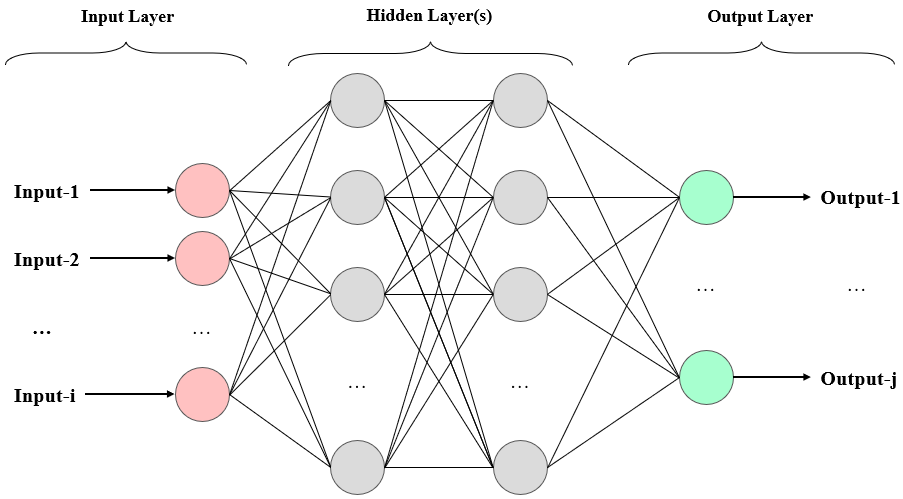


Figure. 1. The Illustrative Structure of the Neural Network for Classification

In the literature, accuracy, sensitivity, specificity, and precision statistics are used to test the model performance (Kılıç Depren et al., 2017). When the definitions of these metrics are adapted to the data set in this study, they answer the following questions:

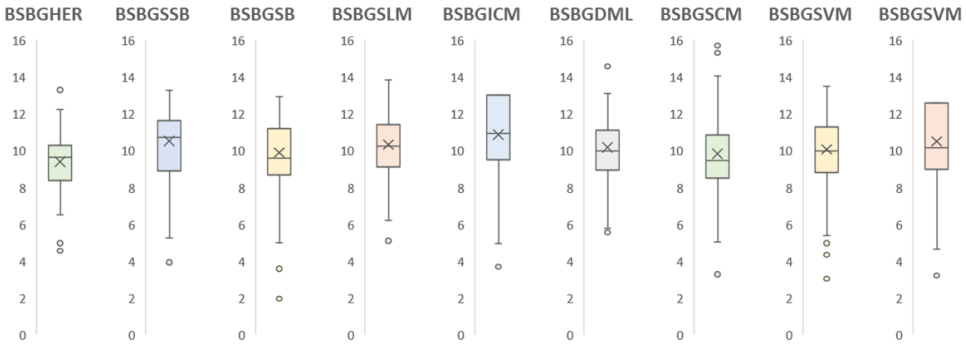
1. Accuracy: How many students are correctly predicted (classified) out of all the students?
2. Precision: How many of those whom the model is predicted as successful students (who have higher scores than the country average) are successful?
3. Sensitivity: Of all the students who have lower scores than the country average (flagged as 0 in the study), how many of those are correctly predicted (classified)?
4. Specificity: Of all the students who have higher scores than the country average (flagged as 1 in the study), how many of those are correctly predicted (classified)?

In order to perform the ANN model, "caret" and "nnet" packages in R Studio are used.

Results

Preliminary Analysis

In Turkey, the percentage of students who have a higher mathematics score than Turkey's average, which is 496, is 48.3%. The percentage of students who are absent from school once a month or more is 24% and almost half of the students have their own room and internet connection in Turkey. Figure 2 presents the descriptive statistics and Box-Plot of indexed variables in Turkey.

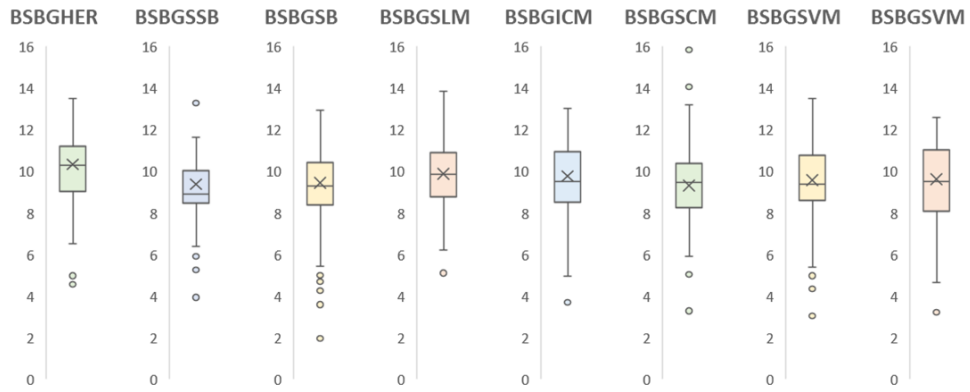


	BSBGHER	BSBGSSB	BSBGSB	BSBGSLM	BSBGICM	BSBGDML	BSBGSCM	BSBGSVM	BSBGSVM
Min	4.55	3.92	1.95	5.09	3.70	5.57	3.28	3.04	3.21
Q1	8.36	8.90	8.67	9.13	9.52	8.95	8.52	8.82	8.99
Q2	9.65	10.71	9.57	10.25	10.92	9.99	9.45	9.98	10.17
Q3	10.27	11.62	11.19	11.43	13.02	11.10	10.85	11.30	12.57
Max	13.52	13.27	12.94	13.85	13.02	14.67	15.85	13.48	12.57
Mean	9.40	10.52	9.89	10.33	10.87	10.17	9.82	10.08	10.50
SD	1.79	1.98	1.84	1.94	1.87	2.02	2.36	2.07	1.83
CV	19%	19%	19%	19%	17%	20%	24%	21%	17%
Skewness	-0.16	-0.26	0.20	-0.16	-0.65	0.21	0.24	-0.25	-0.50
Kurtosis	0.24	-0.42	-0.10	0.01	0.13	0.29	1.16	0.27	-0.31

Figure. 2. Descriptive Statistics and Box-Plot of Variables in Turkey Dataset

Based on Figure 2, the average values (Avg.) of the variables vary between 9.40 and 10.87. These variables do not have many outliers and their standard deviations (SD) are relatively close to each other. Besides, instructional clarity in mathematics lessons (BSBGICM) and students' value mathematics (BSBGSVM) variables have negatively skewed distributions. Unlike the other variables, student confidence in mathematics (BSBGSCM) has a light-tailed distribution.

In Singapore, the percentage of students who have a higher mathematics score than the country average, which is 616, is 52.2%. The percentage of students who are absent from school once a month or more is 13% and 60% of the students have their room and internet connection in Singapore. Figure 3 shows the descriptive statistics and Box-Plot of variables in Singapore.



	BSBGHER	BSBGSSB	BSBGSB	BSBGSLM	BSBGICM	BSBGSCM	BSBGSVM	BSBGSVM
Min	4.55	3.92	1.95	5.09	3.70	3.28	3.04	3.21
Q1	9.65	8.46	8.36	8.95	8.52	8.52	8.58	8.09
Q2	10.27	9.41	9.29	9.87	9.52	9.67	9.36	9.53
Q3	11.49	10.71	10.42	11.15	10.92	10.85	10.77	11.02
Max	13.52	13.27	12.94	13.85	13.02	15.85	13.48	12.57
Mean	10.51	9.53	9.53	10.08	9.89	9.65	9.66	9.75
SD	1.47	1.77	1.74	1.79	1.87	2.18	1.70	1.89
CV	14%	19%	18%	18%	19%	23%	18%	19%
Skewness	-0.26	0.35	0.35	0.06	0.06	0.04	0.33	-0.09
Kurtosis	0.34	0.33	0.34	0.25	-0.21	1.22	0.51	-0.39

Figure. 3. Descriptive Statistics and Box-Plot of Variables in Singapore Dataset

According to Figure 3, the average values (Avg.) of the variables vary between 9.53 and 10.51, which are slightly higher than in Turkey. Standard deviations (SD) of these variables are relatively close to each other and lower than in Turkey. Besides, students' sense of school belonging (BSBGSSB), student bullying (BSBGSB), and students' value mathematics (BSBGSVM) variables have positively skewed distributions. Similar to Turkey, student confidence in mathematics (BSBGSCM) has a light-tailed distribution in Singapore.

Multilayer Perceptron Modelling

The first step of the analysis is to split the dataset into two as 80% training and 20% test set taking into consideration of the dependent and independent variable distributions. After splitting the dataset, the Multilayer Perceptron (MLP) algorithm, which is one of the neural network algorithms, is performed in train and test datasets for both countries. The algorithm setup is defined as performing a 10-fold 5-repeat cross-validation approach for preventing overfit and reaching robust estimations. Besides, the decay and the number of neurons is differentiated to reach a high level of accuracy. In this context, the decay parameter is included in the model at 5 different values from 0.1 to 0.5 and the number of neurons is set at 10 different values from 1 to 10. In Table 2, model performance statistics are given for both countries.

Table 2. MLP Model Performance Statistics in Turkey and Singapore

	TURKEY		**SINGAPORE**	
Criteria	**Train (n: 3.073)**	**Test (n: 767)**	**Train (n: 3.822)**	**Test (n: 955)**
Accuracy	75.4%	75.4%	72.1%	72.8%
Sensitivity	70.8%	72.2%	78.6%	82.3%
Specificity	79.6%	78.3%	64.9%	62.4%
Precision	74.5%	75.1%	73.6%	76.4%

According to Table 2, overall accuracy statistics are at 75% and 72% level in Turkey and Singapore, respectively. Also, the accuracy statistics of train and test samples are not differentiated in both countries. The sensitivity value of the model is lower than the specificity values of the model in Turkey, vice versa in Singapore. This result shows that the model predicts students who have lower achievement than the country's average more accurately in Turkey. On contrary to Turkey, the model can predict students who have higher achievement than the country's average more accurately in Singapore. Also, precision values are very close in train and test samples in both countries.

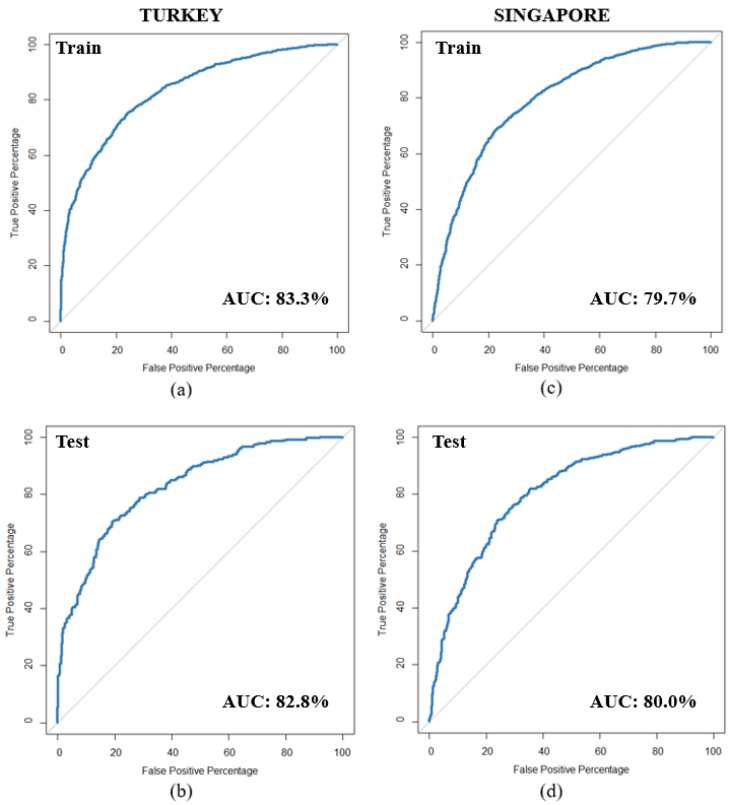


Figure. 4. Receiver Operating Characteristics (ROC) Curve and Area Under Curve (AUC) Statistics in Turkey and Singapore

The ROC curve figures of the train and test samples for Turkey are given in Figure 4(a) and (b) while these figures for Singapore are given in Figure 4(c) and (d). Besides, AUC statistics are almost higher or equal to 80% for each sample in both countries. Since the higher the AUC, the better the model is at distinguishing between students with low and high achievement, the level of AUC of the model used is at the satisfactory level in Turkey and Singapore.

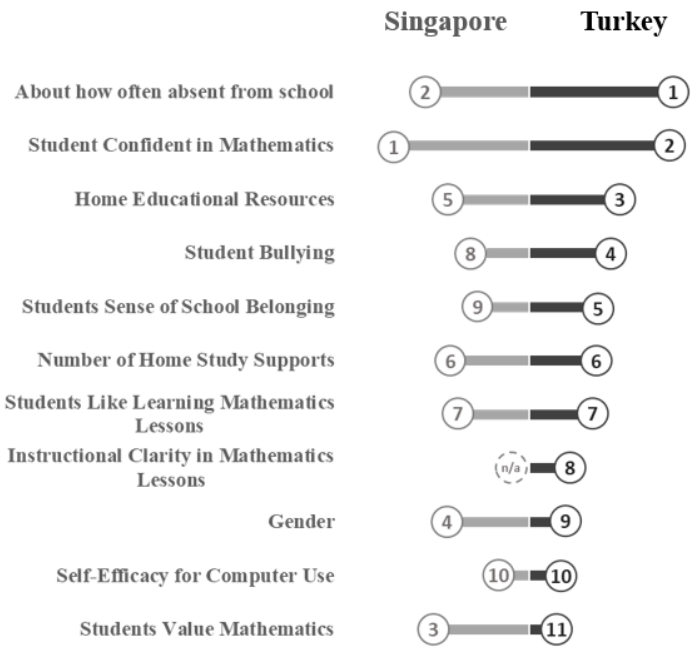


Figure. 5. The Importance of Variables Affecting Students' Achievement in Turkey and Singapore

According to Figure 5, the two most influencing factors that have a relatively higher impact on students' achievement in Turkey are the frequency of absenteeism from school and students' confidence in mathematics, respectively. The relative importance of home educational resources, student bullying, sense of belonging, number of home study support, and like learning mathematics are close to each other in Turkey. Besides, the relative impact of gender and self-efficiency for computer use on students' achievement is relatively lower than other factors. Similar to Turkey, students' confidence in mathematics and the frequency of absenteeism from school are the most influencing factors affecting students' achievement in Singapore. On contrary to the results obtained from the dataset of Turkey, students value mathematics and gender have a significant impact on students' achievement. Except that the two most important factors are common, the importance of home educational resources, student bullying, and sense of belonging are more important factors in Turkey while gender and students value mathematics are more important for students' achievement in Singapore.

Discussion

Turkey remained below the OECD average in the field of mathematics in the TIMSS 2019 study although the mathematics scores of the students in Turkey increased significantly compared to the previous study. In this case, it is not possible to say that mathematics achievement has increased for Turkey. The main purpose of this study is to determine which variables play an important role in increasing Turkey's mathematics score. It is based on the idea that the best way to determine this situation would be to make a comparison with the most successful country at mathematics, which is Singapore in TIMSS 2019. Thus, it is thought that it will be a guiding study for educational scientists about what to do to increase mathematics success. The dataset of this research is composed of 8th-grade students in Turkey and Singapore obtained from TIMSS 2019 study. With this dataset, the crucial factors that have a significant impact on students' mathematics achievement are determined using the ANN approach for both countries. Thus, the similarities and differences can be evaluated between Turkey and Singapore.

Based on the analysis results of the study, the frequency of absenteeism and students' confidence in mathematics are the top two crucial factors for both Turkey and Singapore. However, it is a remarkable point that the other important variables affecting mathematics achievement in Turkey have differentiated from Singapore. In Turkey, home educational resources, student bullying, and a sense of belonging are more important than gender and students' perception of value at mathematics. Contrary to Turkey, the order of these variables in terms of importance on the achievement in Singapore is lower, except for students' perception of value at mathematics.

Studies in the extant literature stated that the issue of absenteeism from school is a concept that is not easy to explain, as it has many different reasons behind it. Thus, these reasons are divided into two concepts: authorized (accepted by the school such as illness) and unauthorized (not acceptable by school) (Hancock et al., 2018). Also, it is revealed that absenteeism hurts students' achievement regardless of the type of absenteeism (Aucejo & Romano, 2016; Gershenson et al., 2017; Hancock et al., 2017). Similar to the studies in the literature, there is a strong negative correlation between absenteeism and students' achievement in both countries. But it is revealed that the level of absenteeism in Turkey is higher than in Singapore, which is an improvement area for Turkey. Since the reason behind the absenteeism can be different from student to student, the first action should be to identify the main reason for absenteeism to prevent the high level of absenteeism in Turkey. These reasons can be low socio-economic status, lack of strong student-teacher relationships, strict school rules, crowded classrooms, lots of homework, lack of lessons materials, peer influence, and bullying (Komakech & Osuu, 2014; Shahzada et al., 2011; Suhid et al., 2012; Wadesango & Machingambi, 2011). The second action is to create student-based-customized action plans to move forward in terms of decreasing the students' absenteeism. However, the units that will create the action plans vary according to the nature of the action. For example, students' low socio-economic status and crowded classrooms are problems to be taken an action by the government while lack of strong student-teacher relationships, strict school rules, lots of homework, and lack of lesson materials should be handled by the school management. Peer influence and bullying are factors that should be handled by both students' families and teachers.

Self-confidence or anxiety about something is a part of our life. Furthermore, in childhood, especially at the very beginning of educational life, these terms have an extremely important impact on reaching a high level of achievement for a student. In the literature, many researchers have been pointed out that high self-confidence in mathematics comes to a high level of success, or a high level of anxiety brings a low level of success (Gopal et al., 2020; Khun-Inkeeree, 2017; Kunhertanti & Santosa, 2018; Nankung et al., 2019; Olson & Stoehr, 2019; Suryadi & Santoso, 2017). Similar to studies in the literature, it is revealed that confidence in mathematics has a significant impact on students' mathematics achievement in both Turkey and Singapore. Thus, action plans that can improve students' self-confidence in mathematics should be taken into consideration to reach a high level of mathematics achievement in both Turkey and Singapore. These action plans are generally created by the government, teachers, and families.

In the literature, many researchers state that home educational resources are highly correlated to students' achievement (Boulifa & Abdelali, 2022; Çoban & Kamış, 2019; Kılıç Depren et al., 2017). In addition, home educational

resources are highly correlated to students' socio-economic and cultural status as well (Erdem & Kaya, 2021; Munez et al., 2021). Besides, in Information and Communication Technology (ICT) Usage survey conducted by TUİK, it is revealed that %85 of people has an internet connection in Turkey and 62% of them had a fixed broadband (ADSL, cable, optic fibre, etc.) (Turkish Statistical Institute, 2022). This finding also shows that the familiarity of information technology should be improved in Turkey.

It is found that gender is an important factor affecting students' achievement (Ergün, 2019; Innabi & Dodeen, 2018; Telteman & Windzio, 2019; Zhou et al., 2019). However, in this study, it is found that the importance of gender is relatively low in Turkey while it has a great impact on Singapore.

The importance level of the number of home study supports, students like learning mathematics lessons, and self-efficacy for computer use in Turkey and Singapore is equal. Home study support and self-efficacy for computer use are related to students' socio-economic and cultural status. Thus, actions about these factors are highly correlated to the economical welfare of the government or the priorities of the government to spend the finite sources to more than one improving area.

To sum up, the main difference between Turkey and Singapore in terms of educational achievement is that educational reforms done by the Turkish government are too general and cannot be implemented in all the areas of the country. Although educational reforms that are suitable to the changing technological environment are taken into consideration in the 10th development plan in 2013, it is too late to improve the awareness. On the other hand, the government of Singapore has started educational reform in the 1990s. Also, in 1997, the entire education system from pre-school to university has changed, which is named "the big bang in Singapore's educational reforms" (Gopinathan, 2001). With this action, the curriculum has been revised as a customized learning approach rather than a common curriculum. In this way, the Singaporean educational system can be a reference point for Turkey. Once all these educational actions are taken aside to implement in the Turkish educational system in the future plan, absenteeism and mathematics anxiety (or self-confidence in math) can be solved using some basic actions with the student's family and school administration together.

Conclusions

In leading countries in the education system, the main purpose is to train individuals who can use analytical thinking skills in real-life problems effectively. Effective mathematics education is needed for the development of analytical thinking skills as well. With the results of PISA and TIMMS, mathematics, science, and reading education levels of countries can be measured objectively. Thus, the main areas to be improved can be identified and action plans can be created using the best practice country as a reference point.

This study, it is aimed to find out factors that have a significant impact on students' achievement using the Multilayer Perceptron Algorithm. With this approach, factors affecting mathematics achievement in both Turkey and Singapore are determined with a model with approximately 80% AUC statistics. In addition, it is shown that the importance of these factors is differentiated between Turkey and Singapore. Based on the variable importance analysis, absenteeism and confidence in mathematics are crucial factors for students' mathematics achievement. Also, home educational resources, number of home study support, and self-efficacy for computer use have a significant impact on students' mathematics achievement. These factors are highly correlated to students' socioeconomic status and wealth. Thus, the government must prevent inequality of opportunity in areas that are effective directly or indirectly in education. In addition, expenditure on education per capita should be reallocated by policymakers to improve the educational system.

Recommendations

In the light of findings in the study, it is suggested to increase the level of awareness of the negative impact of absenteeism by creating training programs for families to point out the long-term impact of absenteeism on students' achievement. School management should set clear explanations on guidelines about the attendance of school and also, should cooperate with several welfare organizations to support students and families both financially and mentally. Furthermore, several daily out-of-school activities should be planned to improve the student-teacher relationship.

In order to come over the mathematic anxiety, first, the government should add how to use mathematics in our daily life in the current curriculum via daily life problems. Secondly, teachers should prepare a section about playing math games or let students change the rules of the current game or create a new math game. Thus, students can involve in a game on mathematics without feeling anxiety. Thirdly, teachers encourage students to discuss their opinion about a math problem without fear of making mistakes.

In order to improve home educational resources; (a) the government should support parents who have low socioeconomic status with books, computers, tablets, and the internet to improve students' achievement; (b) parents who have high socioeconomic status should provide their children with a desk to study at, a room of their own if possible, a computer, a tablet, etc. It is very hard to apply the first solution to all the areas of a country but it can be started with the area where people have the lowest socioeconomic status. Furthermore, family support has a great

impact to apply the second solution. Thus, school management or non-governmental organizations should take various actions to raise awareness of families on this issue.

Limitations

There are some limitations in this research although it is a reference point for further research. First, only student-level factors are included in the study but teacher, school, and country-related factors should be taken into consideration. Second, the result of Turkey is only compared to Singapore in terms of mathematics achievement, but other countries should also be taken into consideration in the comparison of Turkey.

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All authors have contributed equally in conceptualization, design, statistical analysis, writing, and editing/reviewing.

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