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Investigation of Variables Explaining Science Literacy in PISA 2015 Turkey Sample *

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Abstract

The purpose of this study was to examine the variables that explain science literacy with the answers given by Turkish students to the Program for International Student Assessment (PISA) 2015 student questionnaire. The Turkish sample of the research, which was conducted in a relational scanning model, is composed of 5895 students selected through a stratified sampling design. The sample of the study consists of 3052 people who remained after the data containing missing values were removed. In this study, Chi-squared Automatic Interaction Detection (CHAID) method, which is one of the data mining decision tree algorithms, was used for data analysis. As a result of the analysis, it was concluded that the variable that best explains the science literacy of Turkish students is "the number of books in the home". Other variables explaining the science literacy of Turkish students were also investigated in detail. In the research, gain values were examined to determine the most effective node in separating successful and unsuccessful students. As a result, it was seen that the most effective node consisted of students with science self-efficacy among students who had more than 200 books at home, and those who had more than 40 course hours in a week at school.

Keywords: PISA, science literacy, data mining, CHAID analysis

Introduction

In this period, in which we live in the information age, there are new developments in assessment every day. Miller et al. (2009, pp. 28) define assessment as "a general term that includes the full range of procedures used to gain information about student learning (observations, ratings of performances or projects, paper-and-pencil tests) and the formation of value judgments concerning learning progress". Russell and Airasian (2012, pp. 10) defined it as "a process of collecting, synthesizing and interpreting information in order to make a decision". As it can be understood from these definitions, the purpose of determining the situation is not to make a judgment about the student but to make an inference about his learning and performance. Due diligence studies are carried out at both national and international levels.

PISA is an international due diligence study. PISA is one of the largest international education studies organized by the Organization for Economic Cooperation and Development (OECD) that evaluates students' knowledge and skills in the fields of science, mathematics, and reading skills. This project covers the ability of students aged 15 who have reached the end of compulsory education to use what they have learned in school and in their out-of-school life, not how much they can remember what they have learned. Furthermore, it aims to determine the extent to which they can benefit from their knowledge and skills in order to understand new situations they will encounter, solve questions, make predictions about unfamiliar subjects, and make judgments. This purpose of PISA distinguishes it from other evaluation projects (Ministry of National Education [MoNE], 2010).

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The experts in the countries participating in the PISA project form the evaluation framework and conceptual qualifications of the research, which are then approved by the joint decision of the participating countries as a result of the interviews. In this regard, a new understanding of the concept of "literacy" has been formed. The concept of literacy is defined as the capacity of students to make inferences from what they have learned in order to use their knowledge in daily life, to make logical inferences, to interpret and solve problems related to various situations. In this project, 15-year-old students are not asked to have learned everything they need like adults; they are expected to reach a solid foundation in science, mathematics and reading skills, to continue this learning throughout their lives and to be able to use the knowledge they have flexibly in their daily lives (MoNE, 2010).

The PISA project is carried out in three-year cycles. In each cycle, one of the areas of reading skills, mathematics and science literacy is examined in more detail, while the other areas are examined in less detail. PISA 2015 research focused on science literacy.

Science literacy is defined in PISA 2015 as "the ability to deal with science-related ideas and issues related to science as an active citizen". An individual who is scientifically literate wants to participate in speeches and conversations in the field of science-based on certain elements. For this, scientific explanation, scientific inquiry, and evaluation competencies are required. In science literacy, students' affective characteristics, such as their interests and attitudes towards science, can increase their motivation and affect their participation (MoNE, 2016).

Science literacy is important both at the national and international levels. Because humanity confronts great challenges in providing adequate water and food, controlling diseases, producing enough energy, and adapting to climate change. However, many problems also arise at the local level, where individuals may be faced with decisions regarding practices that affect their health and food resources, the appropriate use of materials, the use of new technologies, and energy use. In order to cope with all these difficulties, the contribution of science and technology is required. However, as discussed by the European Commission, "Unless young people have a certain scientific awareness, it is not a subject of conscious discussion." Also, that doesn't mean turning everyone into a scientific expert. But it is necessary to ensure that they take an enlightened role in making choices that affect their environment and to enable them to broadly understand the social implications of debates among experts. Given that the knowledge of science and science-based technology makes a significant contribution to the personal, social and professional lives of individuals, the understanding of science and technology is very important for the "preparation for life" of a teenager (OECD, 2017).

Everyone has individual differences, so it is not possible for all individuals to be scientifically literate at the same level. The important thing is to raise individuals who are interested in science, who can transfer and use what they have learned in their lives, and who have a level of knowledge to have a say in science-related issues in society. In this process, the desire for lifelong learning should be based. Some aim to pursue a career in science, while others seek leadership in science-related social issues. The important thing here is to give everyone the opportunity to learn the knowledge and skills that can meet the needs of society. The two main forces that shape our social life are science and technology. Therefore, in our age, societies want citizens to have the capacity to make decisions and make comparisons, when necessary, in the field of science and technology. The purpose of science education, which prepares children for the future, is to raise scientifically literate individuals because science and technology literacy is the basis of being effective in the world (Anagün, 2008).

The PISA application provides detailed information about the countries participating in the research, according to the established reference points, what their education levels are and what measures should be taken throughout the country. Thanks to this project, countries see the deficiencies in the education system, compare them with other countries and eventually find the opportunity to make new regulations regarding education.

In the literature review, many studies were found in which the variables affecting student success in PISA application were examined. In the study of Çeçen (2015), it was determined that the opportunities of the students at home, the cultural richness of the family, the education level of the parents and their positions at the workplace significantly predicted the PISA science literacy scores in 2003, 2006, 2009 and 2012 applications. In Karabay's (2013) study, it was found that the variables of the number of books in the home, having a room of their own, having a computer at home, and the education level of the parents were significant predictors for both PISA applications (2003, 2006, 2009) and application areas (science and mathematical literacy, reading skills). In addition to these, it was found that the variable of quality of educational resources at school was a significant predictor both during PISA applications (2003, 2006, 2009) and for application areas (science and mathematics literacy, reading skills) (Karabay, 2013). In the study of Özer and Anıl (2011), it was determined that the variable that most predicts students' science and mathematics achievement in the PISA 2006 application is the "time devoted to learning" variable. In the study of Anagün (2011), it was determined that the most important factor affecting science literacy in PISA 2006 application was "the time devoted to learning" and this was followed by the variable "inquiry-based learning activities".

In these studies, analysis was mostly made with parametric statistical methods, which require certain assumptions. In these studies, it was stated that assumptions such as missing data, extreme values, multicollinearity problem, normality, linearity, and homogeneity were met. Researchers generally used parametric methods such as factor analysis, analysis of variance, t-test, multiple linear regression, and structural equation modeling. In these studies, in which certain variables were selected from the student questionnaire applied in PISA, a limited number of variables were included in the analysis.

Despite the reforms in education in Turkey, it is quite remarkable that the average of success in the PISA project is below the OECD average. In this study, variables explaining science literacy in the PISA 2015 project were examined. The results of the research are important not only in science literacy but also in terms of taking necessary precautions and eliminating deficiencies in the education system. For this reason, the variables explaining the PISA 2015 science literacy of Turkish students were examined with CHAID analysis, one of the data mining methods. Thus, unlike other studies, the data did not need to provide various assumptions and many categorical and continuous predictor variables could be included in the analysis at the same time.

Purpose of the Study

The general purpose of the study is to examine the variables that explain science literacy with the answers given by Turkish students to the variables selected from the PISA 2015 student questionnaire. In line with the determined purposes, answers to the following questions are sought within the scope of this study:

1. Which predictor variable best explains the science literacy of Turkish students and divides the data set into homogeneous subgroups in the PISA 2015 Turkey sample?
2. Which variables respectively explain the science literacy of Turkish students in the PISA 2015 Turkey sample?
3. What is the order of importance of the predictor variables in classifying science literacy levels in the PISA 2015 Turkey sample?

Method

This research, conducted on Turkish students based on PISA 2015 data, is in a relational screening pattern of screening models.

Sample

In the PISA application, the sample setup is determined according to the stratified random sampling design through national centers. In this setup, the selection criteria (region, program type, school type) of the sample and schools are arranged. 187 schools and 5895 students from 61 provinces participated in the PISA 2015 application representing the 12 Statistical Regional Units Classification (İBBS) in Turkey (MoNE, 2016).

Since answering and not answering the questionnaire items in the student questionnaire used in the study may cause a bias, the missing values in the data set were analyzed first. Little (1988) states that if the missing values are randomly distributed, the list-based deletion method can be used. In this study, it was determined that the missing values were randomly distributed. Therefore, the missing values in the items in the student questionnaire were deleted. As a result, 3052 students who filled out the variables selected from the student questionnaire completely constitute the sample of the research.

Data Collection Tools

The measurement tools used in the research are the science literacy achievement test in the PISA 2015 application and the PISA 2015 student questionnaire applied to the students who answered this achievement test. In order to determine the variables that affect science literacy, student questionnaire items and indices created using these items were examined. The items and indexes selected from the student questionnaire within the scope of this research are given in Table 1.

Table 1

Variables Used in the Research on Science Literacy

	Variables	Description	Items	Number of Items
VARIABLES RELATED TO STUDENT, STUDENT'S FAMILY AND STUDENT'S HOME	ST001	Grade level	ST001Q01TA	1
	ST004	Gender	ST004Q01TA	1
	ST011	Home educational resources	ST011Q01TA, ST011Q02TA, ST011Q03TA, ST011Q04TA, ST011Q05TA, ST011Q06TA, ST011Q07TA, ST011Q08TA, ST011Q09TA, ST011Q10TA, ST011Q11TA, ST011Q12TA, ST011Q16TA	13
	ST012	Number of items at home	ST012Q01TA, ST012Q02TA, ST012Q03TA, ST012Q05NA, ST012Q06NA, ST012Q07NA, ST012Q08NA, ST012Q09NA	8
	ST013	Number of books in home	ST013Q01TA	1
	ST123	Parents emotional support	ST123Q01NA, ST123Q02NA, ST123Q03NA, ST123Q04NA	4
	ST125	Duration in early childhood care	ST125Q01NA	1
	ST126	Duration in early childhood education	ST126Q01TA	1
	MISCED	Mother's education	ST005, ST006	
	FISCED	Father's education	ST007, ST008	
	HISEI	Highest parental occupational status	ST014, ST015	
VARIABLES RELATED TO STUDENT'S OWN LIFE	ST118	Test anxiety	ST118Q01NA, ST118Q02NA, ST118Q03NA, ST118Q04NA, ST118Q05NA	5
	ST119	Achieving motivation	ST119Q01NA, ST119Q02NA, ST119Q03NA, ST119Q04NA, ST119Q05NA	5
	BSMJ	Student's expected occupational status	ST114	

Table 1 (continued)

	Variables	Description	Items	Number of Items
VARIABLES RELATED TO STUDENT'S SCHOOL	ST082	Collaborative problem solving	ST082Q01NA, ST082Q02NA, ST082Q03NA, ST082Q08NA, ST082Q09NA, ST082Q12NA, ST082Q13NA, ST082Q14NA	8
	ST034	Sense of belonging to school	ST034Q01TA, ST034Q02TA, ST034Q03TA, ST034Q04TA, ST034Q05TA, ST034Q06TA	6
	Unfairteacher	Teacher Fairness	ST039	
VARIABLES RELATED TO SCHOOL CALENDAR AND LEARNING TIME	ST060	The number of class periods per week attended in total	ST060Q01NA	1
	ST061	Average number of minutes in a class period	ST061Q01NA	1
	SMINS	Learning time per week in science (min)	ST059, ST061	
VARIABLES RELATED TO SCIENCE LEARNING IN SCHOOL	ST097	Disciplinary climate in science classes	ST097Q01TA, ST097Q02TA, ST097Q03TA, ST097Q04TA, ST097Q05TA	5
	ST098	Inquiry-based science teaching and learning practices	ST098Q01TA, ST098Q02TA, ST098Q03NA, ST098Q05TA, ST098Q06TA, ST098Q07TA, ST098Q08NA, ST098Q09TA, ST098Q10NA	9
VARIABLES RELATED TO STUDENT'S TENDENCY TO SCIENCE	ST092	Environmental awareness	ST092Q01TA, ST092Q02TA, ST092Q04TA, ST092Q05TA, ST092Q06NA, ST092Q08NA, ST092Q09NA	7
	ST093	Environmental optimism	ST093Q01TA, ST093Q03TA, ST093Q04TA, ST093Q05TA, ST093Q06TA, ST093Q07NA, ST093Q08NA	7
	ST094	Enjoyment of science	ST094Q01NA, ST094Q02NA, ST094Q03NA, ST094Q04NA, ST094Q05NA	5
	ST095	Interest in broad science topics	ST095Q04NA, ST095Q07NA, ST095Q08NA, ST095Q13NA, ST095Q15NA	5
	ST129	Science self-efficacy	ST129Q01TA, ST129Q02TA, ST129Q03TA, ST129Q04TA, ST129Q05TA, ST129Q06TA, ST129Q07TA, ST129Q08TA	8
	ST131	Epistemological beliefs	ST131Q01NA, ST131Q03NA, ST131Q04NA, ST131Q06NA, ST131Q08NA, ST131Q11NA	6

Data Analysis

In this study, the analysis of the data was carried out by using the SPSS Statistics 21 package program using the CHAID analysis, one of data mining decision trees algorithms. Decision trees are one of the most used classification methods. The creation and interpretation of decision trees is simpler than other methods. In addition, another advantage of decision trees is that the models they create are successful. In order to be able to classify decision trees in practice, a tree model is created in accordance with the available data, the data set is applied to this model and classification takes place in accordance with the result (Silahtaroğlu, 2013). The CHAID algorithm is one of the most widely used decision tree algorithms.

In this study, it was aimed to determine the variables that best explain science literacy from the variables related to the students themselves, their families, homes, and schools. In PISA 2015, 10 different PVSCIE coded science scores were calculated from the answers given to the achievement tests. Brown and Micklewright (2004) stated that it is difficult to easily combine success statistics into a single number in PISA. In order to combine these success statistics, the average score of each country in different tests can be taken into account (Brown & Micklewright, 2004). The average of these 10 different scores determined for science literacy was taken, and the average science literacy score was formed. Since the mean science literacy score has a correlation of around .95 with 10 different score types, it was chosen as the dependent variable in this study. Then, the mean of the dependent variable obtained was taken ($\bar{X}$=443.23), and this value was determined as the cut-off point. Students with a science literacy score below the determined value were categorized as “unsuccessful”, and students with a science literacy score equal to or higher than the average were categorized as “successful”. After this step, CHAID analysis from the data mining decision tree algorithm was performed to find answers to the research questions.

The performance of the tree model created as a result of the CHAID analysis was determined by the cross-validation method. Validation shows the generalizability of the established model to the universe. In the analysis phase, there are two types of validation: split-sample validation and cross validation (Aksu & Karaman, 2016). In split-sample validation, the data is separated into training and test data. The purpose of separating the data as training and testing is to determine the performance of the model on the data set it encounters for the first time. Some of the datasets are used to train the model, while the rest is used to test the model. In this way, models are produced by testing samples. In cross-validation, the sample is divided into k subsamples or multiples. A data set with a total of n samples is divided into k pieces, each of which contains n/k samples. Each time, a different dataset is reserved for testing, and the remaining k-1 dataset is used for training. This process is repeated k times, and at the end of each classification, the average of the performance values given to the tree is taken, and the performance of the model is determined in this way. In this study, the k number was determined as 10, and the data set was divided into 10 sub-samples.

The most important step in the creation of decision trees is to determine the criteria for branching in the tree or to create the tree structure according to which attribute values. There are various approaches developed for this in the literature. Han et al. (2012) explained these as gain ratio, gini index, χ^2 probability table statistics, and uncertainty coefficient, which takes into account the probability of each attribute value. In this study, χ^2 probability table statistics were used as the branching criterion in the tree.

Results

As a result of the CHAID analysis, a table is given about the correct classification of successful and unsuccessful students. Han et al. (2012) presented criteria to evaluate classification accuracy. These are accuracy (recognition rate), sensitivity (or recall), specificity, precision, F1, and F_{β}. When explaining these, four classifications are used: true positives (TP), true negatives (TN), false positives (FP), and false negatives (FN).

True positives (TP) refer to the positive tuples that were correctly labeled by the classifier. True negatives (TN) are the negative tuples that were correctly labeled by the classifier. False positives (FP) are the negative tuples that were incorrectly labeled as positive. False negatives (FN) are the positive tuples that were mislabeled as negative. The evaluation criteria starting from accuracy are introduced below:

- Accuracy: The percentage of test set tuples that are correctly classified by the classifier.
  [(TP+TN)/(P+N)]
- Sensitivity: The proportion of positive tuples that are correctly identified.
  [TP/P]
- Specificity: The proportion of negative tuples that are correctly identified.
  [TN/N]
- Precision: Measure of exactness (i.e., what percentage of tuples labeled as positive are actually such)
  [TP/(TP+FP)]

- Recall: A measure of completeness (what percentage of positive tuples are labeled as such). it is the same as sensitivity (or the true positive rate)
  [TP/(TP+FN)]=TP/P
- F_1 and F_β: An alternative way to use precision and recall is to combine them into a single measure.

The results related to the classification formed as a result of the analysis are given in Table 2.

Table 2
Classification Table for Success Status

Observed	Predicted		
	Successful	Unsuccessful	Success Percentage
Successful (P)	1207 (TP)	284 (FN)	81
Unsuccessful (N)	565 (FP)	996 (TN)	63.8
Total Percentage	58.1	41.9	72.2

Table 2 shows that 1207 of 1491 successful students were classified correctly in the model and the sensitivity (or recall) was 81%. Similarly, it was determined that 996 of 1561 unsuccessful students were classified correctly, and the specificity was 63.8%. It was seen that 1207 of 1772 students who were classified as successful were really successful, and the precision in classification was 68.1%. When the ratio of 1207 successful students and 996 unsuccessful students who were classified correctly to the total number of students was examined, it was determined that the classification accuracy was 72.2%. Apart from classification, the risk value table showing the margin of error of the model is given. Accordingly, the margin of error of the model was determined as approximately 27.8%.

As a result of the analysis, a decision tree with 52 nodes and 3 branches was formed. This decision tree is given at https://github.com/serifezeybekoglu/karar_agac/blob/main/karar_agac%C4%B1.pdf. Predictive variables explaining the students' science literacy, their order of importance on the dependent variable, and the frequency and percentage values related to the classification of successful and unsuccessful students are seen in the decision tree. When this tree is examined, the CHAID analysis, in which the average scores of science literacy are determined as the dependent variable, first of all, there is the variable that has the highest effect on the dependent variable.

There are 3052 students in this study. It is seen that 48.9% (1491) of the students were classified as successful and 51.1% (1561) as unsuccessful. According to the results of the CHAID analysis, among the items selected from the student questionnaire, the variable that best explains the science literacy of the students was the “number of books in home” variable (χ^2=326.14, p=.000). It was determined that five branches occurred at the starting node of this variable in question. It is seen that students who have books between “0-10” at home gather in Node 1. Students in this group constitute 21.8% of the entire data set, and it was determined that the majority of these students (73%) were unsuccessful. It is seen that students who have books between “11-25” at home gather in Node 2. It was determined that the majority of these students (61.3%) were unsuccessful. It is seen that the students who have “26-100” books at home gather in Node 3. It was determined that the majority of these students (59%) were successful. It is seen that students who have books between “101-200” in their home gather in Node 4. It was determined that the majority of these students (66.9%) were successful. It is seen that the students, who have more than 200 books in their homes, are gathered at Node 5. It was determined that the majority of these students (75.8%) were successful. It is seen that students are significantly more successful as the number of books in their homes increases.

It was determined that the variable that best explains the science literacy of the students who have books between “0-10” at home is the item “How informed are you about the use of genetically modified organisms?”, which is related to environmental awareness (χ^2=62.86, p=.000). Two branches occurred at the first node to the variable in question. It is seen that the students who responded to this item as “I have never heard of this" and "I have heard about this but I would not be able to explain what it is really about" gathered in Node 6. It was determined that the majority of these students (90.7%) were unsuccessful. It is seen that the students who answered the above item as "I know something about this and could explain the general issue" and "I am familiar with this and I would be able to explain this well" gathered in Node 7. It was determined that the majority of these students (62.5%) were unsuccessful.

It was determined that the variable that best explains the science literacy of students who do not have knowledge about the use of genetically modified organisms is the item "Do you think problems associated with the use of genetically modified organisms will improve or get worse over the next 20 years?", which is related to environmental optimism (χ^2=19.34, p=.000). According to the variable in question, two branches occurred in the sixth node. It is observed that the students who responded to this item in the form of "improve" and "stay about the same" were collected in Node 20. It was determined that almost all of these students (99.2%) were unsuccessful. It is seen that the students who answered "get worse" to the above item gathered at Node 21. It was determined that the majority of these students (82.9%) were unsuccessful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of the students who have knowledge about the use of genetically modified organisms is the item "This school year, approximately how many hours per week do you spend learning in addition to your required school schedule in school science?" (χ^2=40.72, p=.000). According to the variable in question, two branches occurred in the seventh node. The time that students who answered this item allocate to learning for school science varies between 0-800 minutes. It is seen that students with 200 minutes or less of time spent on learning congregate at Node 22. It was determined that the majority of these students (77.9%) were unsuccessful. Students with more than 200 minutes of learning each week for the school science seem to congregate at Node 23. It was determined that the majority of these students (52.4%) were successful. It is seen that students are significantly more successful when the time allocated to learning increases. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of students who have "11-25" books at home is the item "Do you think problems associated with the nuclear waste problem will improve or get worse over the next 20 years?" (χ^2=71.36, p=.000). According to the variable in question, two branches occurred in the second node. It is seen that the students who responded to this item as "improve" and "stay about the same" gathered in Node 8. It was determined that the majority of these students (84%) were unsuccessful. It is seen that the students who answered "get worse" to the above item gathered at Node 9. It was determined that the majority of these students (52.4%) were unsuccessful.

It was determined that the variable that best explains the science literacy of students who approach the nuclear waste problem more optimistically is the item "How many of tablet computers are there at your home" (χ^2=14.91, p=.000). According to the variable in question, two branches occurred in the eighth node. It is seen that students who do not have any tablet computers at home gather in Node 24. It was determined that the majority of these students (94.3%) were unsuccessful. It is seen that students who have at least one tablet computer at home gather in Node 25. It was determined that the majority of these students (75.8%) were unsuccessful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of students who think that the nuclear waste problem will get worsen is the item "In a normal, full week at school, how many class periods are you required to attend in total?" (χ^2=52.35, p=.000). According to the variable in question, four branches occurred in the ninth node. The number of class periods attended by students who answered this item in a week varies between 10-60 hours. It is seen that students with 39 and less than 39 class periods in a week gather in Node 26. It was determined that the majority of these students (67.1%) were unsuccessful. It is seen that the students who have 40 class periods per week at the school gather at Node 27. It was determined that the majority of these students (60.3%) were successful. It is seen that the students whose number of class periods is between 40 and 45 per week are gathered in

Node 28. It was determined that the majority of these students (74.5%) were unsuccessful. It is seen that students with more than 45 class periods in a week gather in Node 29. It was determined that the majority of these students (55.7%) were successful. It is seen that the students who have 40 hours of class periods and over 45 hours in a week at school are more successful. However, it is also seen that the number of class periods more than 40 does not increase the success anymore. After these four branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of students who have between "26-100" books at home is the item "In a normal, full week at school, how many class periods are you required to attend in total?" (χ^2=92.85, p=.000). According to the variable in question, four branches occurred in the third node. It is seen that students with 39 and less than 39 class periods in a week gather in Node 10. It was determined that the majority of these students (58.4%) were unsuccessful. It is seen that the students who have 40 class periods per week at school gather in Node 11. It was determined that the majority of these students (72.1%) were successful. It is seen that students whose number of class periods between 40 and 45 per week at school are gathered in Node 12. It was determined that the majority of these students (65%) were unsuccessful. It is seen that students with more than 45 class periods per week at school gather in Node 13. It was determined that the majority of these students (58.2%) were successful. It is seen that the students who have 40 hours of class periods and more than 45 hours in a week at school are more successful. However, it is also seen that the number of class periods more than 40 does not increase the success anymore.

It was determined that the variable that best explains the science literacy of students who attend school for 39 class periods or less in a week, is the item "How informed are you about the use of genetically modified organisms?" (χ^2=18.82, p=.000). According to the variable in question, two branches occurred in the tenth node. It is seen that the students who responded to this item as "I have never heard of this" and "I have heard about this but I would not be able to explain what it is really about" gathered at Node 30. It was determined that the majority of these students (80.3%) were unsuccessful. It is seen that the students who answered the above item as "I know something about this and could explain the general issue" and "I am familiar with this and I would be able to explain this well" gathered at Node 31. It was determined that the majority of these students (51.4%) were successful. It is seen that students with better environmental awareness are significantly more successful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of the students whose class periods in a week is 40 at school is the "Students' expected occupational status" scale, which is related to the student's own life (χ^2=56.02, p=.000). The scores students get from this scale range from 16 to 89. Higher scores on the scale indicate higher levels of expected occupational status. According to the variable in question, four branches occurred at the eleventh node. It is seen that students who score 61 or less from this scale gather at Node 32. It was determined that the majority of these students (52.3%) were successful. It is seen that students who score between 61 and 70 on the scale gather at Node 33. It was determined that the majority of these students (84.2%) were successful. It is seen that students who get 71 points from the scale in question gather at Node 34. It was determined that the majority of these students (61.8%) were successful. It is seen that students who score above 71 on this scale gather at Node 35. It was determined that the majority of these students (80.3%) were successful. After these four branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of the students whose class periods in a week is between 40 and 45, is the item "learning time (minutes per week) in science" (χ^2=18.75, p=.000). According to the variable in question, two branches occurred in the twelfth node. It is seen that students who spend 200 minutes or less on learning time gather at Node 36. It was determined that the majority of these students (89.1%) were unsuccessful. It is seen that students with more than 200 minutes of learning time each week for science class gather at Node 37. It was determined that the majority of these students (50.6%) were unsuccessful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of students who have more than 45 class periods per week at school is the item "Is there a computer you can use for school work in your home?” (χ^2=13.08, p=.000). According to the variable in question, two branches occurred at the thirteenth node. It is seen that students who have a computer at home that they can use for school work gather at Node 38. It was determined that the majority of these students (69.1%) were successful. In this way, it is seen that students who do not have a computer congregate at Node 39. It was determined that the majority of these students (73.9%) were unsuccessful. It is seen that students who have a computer at home that they can use for school work are significantly more successful.

It was determined that the variable that best explains the science literacy of students who have books between “101-200” at home is the item “When learning school science at school, how often activity that students are allowed to design their own experiments occur?” (χ^2=32.94, p=.000). According to the variable in question, three branches occurred in the fourth node. It is seen that the students who answered this item as “in all lessons” gathered in Node 14. It was determined that the majority of these students (66%) were unsuccessful. It is seen that the students who answered the item as “in most lessons” and “in some lessons” gathered in Node 15. It was determined that the majority of these students (67.8%) were successful. It is seen that the students who answered this item as “never or hardly ever” gathered in Node 16. It was determined that the majority of these students (79.3%) were successful.

It was determined that the variable that best explains the science literacy of the students who stated that they were allowed to design their own experiments in “in all lessons” at school is the item “How much do you disagree or agree with the statement that a good way to know if something is true is to do an experiment” (χ^2=12.56, p=.001). According to the variable in question, two branches occurred at the fourteenth node. It is seen that students who answered “I agree, I disagree, and I strongly disagree” about the importance of experimenting gathered in Node 40. It was determined that the majority of these students (86.2%) were unsuccessful. It is seen that the students who answered “strongly agree” to the importance of experimenting gathered in Node 41. It was determined that the majority of these students (61.9%) were successful. It is seen that students who give importance to experimentation are significantly more successful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of the students who stated that they were allowed to design their own experiments as “in most lessons” and “in some lessons” at school is the item “Do you think problems associated with the nuclear waste problem will improve or get worse over the next 20 years” related to environmental optimism (χ^2=16.45, p=.000). According to the variable in question, two branches occurred at the fifteenth node. It is seen that the students who responded to this item as “improve” and “stay about the same” gathered in Node 42. It was determined that the majority of these students (60%) were unsuccessful. It is seen that the students who answered “get worse” to the above item gathered in Node 43. It was determined that the majority of these students (76.9%) were successful. It is seen that students who think that this environmental problem will worsen in the last 20 years are significantly more successful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of the students who stated that they were allowed to design their own experiments as “never or hardly ever” at school is the item “learning time (minutes per week) in science” (χ^2=19.69, p=.000). According to the variable in question, two branches occurred at the sixteenth node. It is seen that students who spend 150 minutes or less on learning gather in Node 44. It was determined that the majority of these students (62.5%) were unsuccessful. It is seen that students with more than 150 minutes of learning time each week for science gather at Node 45. It was determined that the majority of these students (85.7%) were successful. It is seen that students are significantly more successful when the time they spend on learning increases. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of students who have books “more than 200” at home is the item “In a normal, full week at school, how many class periods are you required to attend in total?” (χ^2=35.22, p=.000). According to the variable in question, three branches occurred in the fifth node. It is seen that students with 39 and less than 39 class periods in a week gather in Node 17. It was determined that the majority of these students (51.2%) were unsuccessful. It is seen that students who have 40 class periods per week at school gather in Node 18. It was determined that the majority of these students (86.8%) were successful. It is seen that students who have more than 40 class periods in a week at school gather in Node 19. It was determined that the majority of these students (62.5%) were successful. It is seen that the number of class periods more than 40 does not increase the success more.

It was determined that the variable that best explains the science literacy of the students whose number of class periods in a week is 39 or less is the item “Are there technical reference books in your home” (χ^2=7.66, p=.006). According to the variable in question, two branches occurred at the seventeenth node. It is seen that students who have technical reference books at home gather in Node 46. It was determined that the majority of these students (64.3%) were successful. It is seen that students who do not have such a technical reference book gather in Node 47. It was determined that the majority of these students (80%) were unsuccessful. It is seen that students who have technical reference books at home are significantly more successful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of students whose number of class periods in a week is 40 at school is the item “My parents encourage me to be confident” (χ^2=15.50, p=.000). According to the variable in question, two branches occurred at the eighteenth node. It is seen that students who answered “strongly disagree” about receiving parental encourage gathered in Node 48. It was determined that the majority of these students (66.7%) were unsuccessful. It is seen that the students who answered the item as “disagree, agree, and strongly agree” gathered in Node 49. It was determined that the majority of these students (88.6%) were successful. After these two branches, the branching is finished before a new node is formed.

It was determined that the variable that best explains the science literacy of the students whose number of class periods in a week is more than 40 hours at the school is the item “Identify the better of two explanations for the formation of acid rain” related to science self-efficacy (χ^2=18.04, p=.000). According to the variable in question, two branches occurred at the nineteenth node. It is seen that the students who answered this qualification as “I could do this easily” gather in Node 50. It was determined that the majority of these students (92.6%) were unsuccessful. It is seen that the students who answered this qualification as “I could do this with a bit of effort”, “I would struggle to do this on my own”, and “I couldn’t do this” gather in Node 51. It was determined that the majority of these students (59.5%) were unsuccessful. It is seen that students who have science self-efficacy and say “I could do this easily” are significantly more successful. After these two branches, the branching is finished before a new node is formed.

In addition, the gain values of the obtained nodes are given in Table 3 in order to determine which nodes (roots) are the best to classify successful students in the study and to reveal which of these nodes give more information.

Table 3
Gain Values for Success Status

Node	Node		Gain		Ratio of correct answer	Index
	n	%	n	%		
50. Node	27	0.9	25	1.7	92.6	189.5
49. Node	176	5.8	156	10.5	88.6	181.4
45. Node	105	3.4	90	6	85.7	175.5
35. Node	199	6.5	169	11.3	84.9	173.8
33. Node	95	3.1	80	5.4	84.2	172.4
43. Node	108	3.5	83	5.6	76.9	157.3
38. Node	68	2.2	47	3.2	69.1	141.5
46. Node	28	0.9	18	1.2	64.3	131.6
41. Node	21	0.7	13	0.9	61.9	126.7
34. Node	76	2.5	47	3.2	61.8	126.6
27. Node	290	9.5	175	11.7	60.3	123.5
29. Node	70	2.3	39	2.6	55.7	114.0
23. Node	212	6.9	111	7.4	52.4	107.2
32. Node	149	4.9	78	5.2	52.3	107.2
31. Node	148	4.8	76	5.1	51.4	105.1
37. Node	77	2.5	38	2.5	49.4	101.0
51. Node	37	1.2	15	1.0	40.5	83.0
42. Node	35	1.1	14	0.9	40.0	81.9
44. Node	16	0.5	6	0.4	37.5	76.8
48. Node	6	0.2	2	0.1	33.3	68.2
26. Node	143	4.7	47	3.2	32.9	67.3
39. Node	23	0.8	6	0.4	26.1	53.4
28. Node	98	3.2	25	1.7	25.5	52.2
25. Node	132	4.3	32	2.1	24.2	49.6
22. Node	204	6.7	45	3.0	22.1	45.2
47. Node	15	0.5	3	0.2	20.0	40.9
30. Node	66	2.2	13	0.9	19.7	40.3
21. Node	129	4.2	22	1.5	17.1	34.9
40. Node	29	1.0	4	0.3	13.8	28.2
36. Node	46	1.5	5	0.3	10.9	22.2
24. Node	105	3.4	6	0.4	57	11.7
20. Node	119	3.9	1	0.1	0.8	1.7

When Table 3 was examined, it was determined that the 50th node was the most effective node in separating successful and unsuccessful students (n=25, 1.7%). This node consists of 27 students who have science self-efficacy among the students who have more than 200 books in their home and who have more than 40 class periods in a week and who state “I could easily identify the better of two explanations for the formation of acid rain” and these students are 92.6% correctly classified. In the study, the gain values were examined to determine the second most effective node and it was seen that it was the 49th node (n=156, 10.5%). This node consists of 176 students who received encourage from their parents for self-confidence, among the students who have more than 200 books at home and 40 class periods per week at school, and these students were classified correctly at a rate of 88.6%. It was determined that the third most effective node in explaining successful and unsuccessful students was the 45th node (n=90, 6%). Among the students who have 101-200 books in home, those who were not allowed to design their own experiments in any school science at school, consisted of 105 students, who spent more than 150 minutes on learning each week for the school science, and these students were classified correctly at a rate of 85.7%. In addition, it was observed that the 20th node was the least informative node in distinguishing students' achievements (n=1, 0.1%). This node consists of 119 students who have less than 10 books in the home, who do not have environmental awareness about the use of genetically modified organisms, but who think that "the problem of using genetically modified organisms will improve or remain the same", and these students were classified correctly at a rate of 1.7%.

Discussion and Conclusion

In this study, the variables explaining the science literacy of Turkish students were examined. According to these variables, it was determined that the most important variable explaining the science literacy of 15-year-old students in Turkey is "the number of books in home". According to this research, the percentage of successful students increased significantly as the number of books in home increased. Similar to this result, Kaya and Doğan (2017) examined the variables affecting science literacy according to PISA 2012 data in their study and compared them with other countries. As a result of the research, when the findings were examined, a significant relationship was found between the number of books in the students' homes and science literacy. In addition, a significant difference was observed between the status of students having poetry books and world classics at home and their average science literacy in all four countries studied. Kahraman and Çelik (2017) aimed to determine the personal and environmental factors that affect the success of students according to PISA 2012 results, and it was concluded that the number of books at home was effective in the success of science and reading skills. Karabay (2013) examined family and school characteristics that affect students' success throughout PISA applications. It was concluded that the number of books in students' homes was a statistically significant predictor for both PISA applications (2003, 2006, 2009) and application areas (reading skills, mathematics, and science literacy). In the study of Karweit and Wasik (1992), it was determined that the number of books in the students' homes has a strong effect on science literacy. In a different study, Aslanoğlu (2007) examined the factors related to the reading comprehension skills of 4th-grade students in Turkey, using the PIRLS 2001 student, teacher, and school questionnaire. When the family characteristics of the student were examined, it was concluded that the number of books in the house was the most important family characteristic variable. It is very important for students to gain reading comprehension skills in order to be successful in national and international exams. It is important for students to be able to have books at an early age and to be able to choose reading materials from a wide range during their school years in order to become good readers.

Environmental awareness and environmental optimism of students are also variables that explain science literacy. As a result of the research, similar results were obtained from the literature. Acar and Öğretmen (2012) examined student and school characteristics that affect the science literacy of Turkish students based on PISA 2006 data, and a significant relationship was observed between students' environmental awareness and science performance. Öztürk (2018) examined the variables related to environmental literacy that affect the science literacy of students from different socioeconomic levels based on PISA 2015 data. As a result of the research, a significant relationship was found between students' environmental awareness, environmental optimism, and science literacy. In addition, environmental awareness and environmental optimism differed significantly according to the socioeconomic level of the student. A significant relationship was found between environmental awareness, environmental optimism, and science literacy at all socioeconomic levels. Çelebi (2010) examined the student and school characteristics affecting the science literacy of 15-year-old students in Turkey, Canada, and Sweden in PISA 2006. It was determined that students with environmental awareness and responsibility for sustainable development develop better science literacy skills. However, it was observed that the more awareness and responsibility students have, the less optimistic they are about the future benefits of scientific and technological developments in solving environmental problems. As a result of this study, it is seen that successful students in groups with environmental awareness are more successful than successful students in groups with low environmental awareness. Likewise, it is seen that successful students in groups who think that environmental problems will worsen gradually are more successful than successful students in groups that approach environmental problems more optimistically.

The time students spend on learning science and the number of class periods they attend school in a week are other variables that explain science literacy. As the time students spend on learning science increases, the percentage of successful students also increases significantly. When the class periods in a week at the school were examined, it was observed that the percentage of successful students increased up to 40 class periods, but the increase in the number of class periods was not effective in increasing the percentage of successful students. As a result of the research, similar studies were obtained. Duman (2014) examined the secondary school 6th-grade students' motivation to learn science in terms of various variables, and it was concluded that the motivations of the students did not show a significant difference in terms of the number of science lesson hours per week. Anagün (2011) examined the effects of variables related to learning-teaching processes on students' science literacy within the scope of PISA 2006. When the results of the research were examined, it was seen that the variable that most affected the students' science literacy in terms of learning-teaching processes was the "time devoted to learning". Özer and Anıl (2011) examined the variables affecting students' science and mathematics achievement based on PISA 2006 data. It was concluded that the most important variable affecting students' science achievement is the "time devoted to learning" for science lessons. When the components of this latent variable were examined, it was observed that "time students spare for studying science lessons at school and doing their homework about these lessons", "time allotted to private lessons for science lessons outside of school hours" and "duration of science lessons attended at school", respectively. The results of the research clearly reveal that the increase in the time allocated to education affects success.

Another variable that explains science literacy is having facilities and educational resources provided at home. It was observed that students who have one or more tablet computers at home, who have a personal computer that they can use for school work, and who have a technical reference book are significantly more successful. The results of the study were similar to the literature. In their study based on PISA 2012 results, Kahraman and Çelik (2017) found that the number of computers at home affected students' science and reading skills, and Kaya and Doğan (2017) found that there was a significant relationship between the number of computers and mobile phones at home and science literacy. In Karabay's (2013) study, it was concluded that the student's having a computer at home and having a room of his own were a significant predictor of both PISA applications (2003, 2006, 2009) and application areas (mathematics, science, reading skills). In another study by Karabay (2012), it was found that the facilities provided to the students at home significantly predicted the PISA science literacy scores during the application periods (2003-2006-2009). Likewise, Çeçen (2015) concluded that the facilities provided at home are a significant predictor of science literacy for the PISA application periods (2003, 2006, 2009, 2012). In the study of Chiu (2007), the relationship between the characteristics of students in 41 countries and science literacy was examined. It was concluded that students with educational resources were more successful. Considering that one of the most important variables affecting science literacy is the opportunities provided to students at home and the educational resources that students have, it is clearly seen that enriching the educational environment at home is effective on the success of students.

Students' expected occupational status is one of the variables that affect science literacy. High scores obtained from the scale created to determine the occupational expectations of students in PISA 2015 indicate better levels of expected occupational status. In general, it was observed that the percentage of successful students increased significantly as the occupational expectation increased. As a result of the research, similar studies were obtained. In the study conducted by Can and Taylı (2014) to examine the career development of secondary school students, it was found that students who think of choosing high schools that will take students with exams and high scores have a higher career development level than students who think of choosing high schools that will enter without exams. In many studies in the relevant literature, it has been concluded that the higher the perceived academic achievement, the higher the professional maturity level and career development of the students (Acısu, 2002; Bacanlı & Sürücü, 2011; Bal, 1998; Lawrence & Brown, 1976). However, in some studies, it has been determined that there is no relationship between perceived academic success and professional maturity level (Powell & Luzzo, 1998; Sahranç, 2000). It is very important for students to have a goal in line with their interests and abilities in the education process. Students who do not have any goals and continue to the educational ladder will not contribute enough to themselves or society in their future lives.

Another variable that explains science literacy is students' science self-efficacy. In this study, it was observed that students with high science self-efficacy were significantly more successful. As a result of the research, similar results were obtained with the literature. Usta (2009) examined the affective factors affecting students' science literacy based on PISA 2006 data. As a result of the research, it was determined that the students' self-sufficiency in science had a direct effect on science literacy. The fact that they consider themselves sufficient ensures that their science performance increases. Similarly, in the study conducted on PISA 2006 data, it was concluded that the science self-efficacy of the students was effective in science literacy (Acar & Öğretmen, 2012; Çalışkan, 2008). In a study conducted by Areepattamannil et al. (2011) on 15-year-old students in Canada, it was observed that students' motivational beliefs such as self-efficacy have a positive effect on science achievement. In a study conducted by Sun et al. (2012) based on the results of PISA 2006 in Hong Kong, it was observed that students with high motivation and self-efficacy tended to show a high level of science achievement.

Parental support is also one of the variables that explain science literacy. In this study, it was observed that the success percentage of students who stated that they did not encourage from their families in terms of self-confidence was lower. As a result of the literature review, many studies have been found showing that the support of the family affects student success. However, it has been observed that the studies conducted are mostly related to the socioeconomic status and demographic characteristics of families. In the study of Satır (1996), it was observed that the academic success of the children of the families who are interested in their child, who create a working environment for their child, who honor him when he succeeds, encourage him to work tirelessly when he fails, is higher. In Malkoç's (1993) research, it was concluded that a large part of school success was achieved with the contribution of the family. In the study of Diaz (1989), it was determined that students who are at risk of failing in the classroom and who have low academic success do not have family support and attention. In addition, it was concluded that problems in the family and parental inconsistencies were also negative factors in school success. It has been observed in many studies that findings related to family support affect academic achievement (Epstein, 1991; Fan & Chen, 2001; Yıldırım, 2000).

Epistemological beliefs are the beliefs held by individuals about the process of defining, creating, and evaluating information in mind. In this study, a significant relationship emerged between scientific epistemological belief dimensions, acquiring knowledge, verifying knowledge, and scientific literacy. It has been observed that the success percentage of students who attach great importance to the verification of knowledge is higher. Similar results have been obtained in the literature. In Özbay's (2016) study examining the relationship between middle school students' science achievement and their epistemological beliefs and mental risk-taking tendencies, it was concluded that there is a relationship between epistemological beliefs, mental risk-taking tendency, and science achievement. Evcim et al. (2011) examined the relationship between 8th-grade students' epistemological beliefs, their ability to solve problems they encounter in daily life, and their academic achievements. As a result of the research, a significant relationship was determined between the epistemological beliefs of the students and their academic achievement in general. Cano (2005) found a significant relationship between epistemological beliefs and academic achievement in his study on Hispanic students at the secondary school level. Muis and Franco (2009), in their study examining the relationship between epistemological beliefs, learning approaches and achievement, concluded that epistemological beliefs affect learning approaches and success.

The learning-teaching environment created for students is one of the variables that explain science literacy. As a result of the literature review, it was concluded that the creation of inquiry-based learning environments for students positively affects their science achievement (Akpullukçu, 2011; Anagün, 2011; Atun, 2016; Duban, 2008; Keçeci, 2014). However, in this study, it was determined that the success percentage of students who were prepared an inquiry-based learning environment and were allowed to design their own experiments was lower. The effect of the learning-teaching environment created in the course on student achievement surprisingly gave different results with the literature. It is difficult to explain the reason for this situation. The types of questioning that teachers use in the lesson and how students perceive it should be investigated. When the literature is examined, the types of inquiry are divided into confirmation inquiry, structured inquiry, guided inquiry, and open inquiry. Some researchers state that it is necessary to use open inquiry to develop students' research and higher-order thinking skills, and that structured and guided inquiry is not sufficient (Berg et al., 2003; Chinn & Malthora, 2002). However, some argue that structured and guided inquiry both prevents the student from wasting time and reduces their fear of failing and not reaching the right result (Trautmann et al., 2004). When the results obtained from the literature are examined in general, it can be said that structured inquiry activities are not sufficient to develop students' high-level thinking skills. In many studies, the questioning method used by the teacher in the learning environment was not mentioned. As can be seen, both structured and open inquiry methods have advantages and disadvantages. The important thing is to apply the method appropriate to the level of the students in the learning environment. The questioning methods applied by the teachers in the classroom environment need to be examined in more detail. In addition, based on the item "my teacher allows me to design my own experiments" in the scale, it should be questioned what kind of learning environment successful and unsuccessful students expect in this regard.

Some adjustments can be made in line with the results obtained as a result of this research. It is seen that the variable that best explains students' science literacy is the number of books in home. Therefore, it is recommended to ensure that students have access to various reading materials at home and to improve other facilities provided at home. Parents should be more careful about making their children feel their love, support, and trust. It is suggested that the curricula should be reviewed and the quality of the time allocated to science courses should be given due importance as much as the quantity. The learning and teaching environment should be rearranged to increase students' science self-efficacy and epistemological beliefs. Families and teachers should raise awareness of students and give the necessary support to raise their professional expectations.

This research has some limitations in terms of handling only the data in the PISA 2015 Turkey sample. Researchers can also examine the PISA applications made in different years and examine the changes in the variables that affect success over the years. In addition, the variables affecting success in other countries can be examined and compared with the results obtained in Turkey. Furthermore, it is recommended to re-examine the classification results obtained for science literacy with different analysis methods.

Declarations

Conflict of Interest: No potential conflict of interest was reported by the authors.

Ethical Approval: Secondary data were used in this study. Therefore, ethical approval is not required.

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