Study of the Factors Affecting the Mathematics Achievement of Turkish Students According to Data from the Programme for International Student Assessment (PISA) 2012

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Abstract
This study attempts to determine the factors affecting the mathematics achievement of students in Turkey based on data from the Programme for International Student Assessment 2012 and the correct classification ratio of the established model. The study used mathematics achievement as a dependent variable while sex, having a study room, preparation for mathematics exams, completing homework on time, interest in mathematics, enjoying mathematics and enjoying reading about mathematics were used as independent variables. The studysample consisted of 4478 students participating in PISA 2012. Probit regression analysis was used to analyse the data. According to the findings, it was determined that there was a positive interaction between the dependent variable and all the independent variables except regularly completing homeworkand that the correct classification ratio of the model was 58 (44%).

Keywords: Program for International Student Assessment(PISA), Mathematics achievement, Probit regression

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Introduction

In a rapidly changing and globalising world, one of the greatest objectives of education is to make sure that individuals are able to understand information and therefore the world. With advancements in technology, it has become very easy to obtain information and the ability to use information effectively by applying certain processes of the human mind has become more important (Eryaman, 2007). In this sense, there are exams throughout the world that measure the use and interpretation of information by individuals. One of these large scale exams is PISA, which has the highest number of participants and participating countries and is regarded as the most comprehensive education research in the world. It is held every three years by the Organisation for Economic, Co-operation and Development (OECD) and assesses the fields of mathematics, sciences, and reading skills. The main objective of this study is to reveal how successful countries arein developing the human factors required to achieve maximum levels in every aspect. The desirable outcome for PISA is for the countries involved to review their education systems, not to determine the achievement of students. The objective of PISA can be summarised as follows: to compare the knowledge levels of students in countries with leading roles in determining general policies applied throughout the world with students from other countries; thereby increasing the quality of education and revealing the strong and weak elements of the education systems (OECD, 2013a).

PISA focuses on a different field every year; PISA 2000 focused on reading skills, PISA 2003 on mathematics, PISA 2006 on science, PISA 2009 on reading, and PISA 2012 on mathematics (Uysal, 2009).

The majority of mathematics questions in PISA are related to mathematical literacy and problem solving. Therefore, the basic competence measured with PISA is mathematics literacy. This competence involves envisaging a real life problem as a mathematical problem, then solving the problem through mathematical knowledge, process ability, and reasoning and deciding how the obtained result conforms with real life (OECD, 2013a, 2013b; Wood, 2007). PISA mathematics literacy consists of four aspects: space and shape (geometry), change and relationships (algebra), numbers (arithmetic), and certainty (probability). PISA 2012 focused on literacy concepts as well as students' abilities in mathematical modelling and using mathematical materials and computer software in mathematical modelling (OECD, 2013b).

Turkey's PISA 2003 mathematics average was 423 points; the country ranked 34th of the 41 participating countries and 28th of the 29 OECD countries. Turkey's PISA 2006 mathematics average was 424 points; the country ranked 29th of the 30 OECD countries and 43rd of the 57 participating countries. Turkey's mathematics average in PISA 2009 was 445 points; the country ranked 31st of the OECD countries and 41st of all participating countries. In PISA 2003 Turkey's mathematics average had a 25 point increase from 423 to 448. While there has been a general increase in Turkey's performance, its ranking hasn't changed significantly as its PISA 2003 performance was very low and many other countries have improved their results. In PISA 2003, Turkey's results only surpassed those of Mexico among OECD countries while in PISA 2012 it ranked 32nd (third from the bottom) alongside other OECD countries, including newly joined Chile (Anıl, 2009; Dünya Bankası, 2013; OECD, 2006). The overall increase in the mathematical literacy performance of Turkey was mainly caused by the significant leap between 2006 and 2009,but the same acceleration was not achieved after 2009. One of the possible causes of this is that the profile of 15-year-old students in Turkey changed between 2003 and 2013 because more mathematically disadvantaged students began to be included in the education system (Acar 2012; Zopluoğlu, 2014).

A Review of Related Literature

There are many studies in the literature reporting that the achievements of Turkey have been less than those of other OECD countries. Berberoğlu (2007) studied the PISA 2003 results from a Turkish point of view and determined that the 15-year-old Turkish students demonstrated different academic performance in mathematics literacy depending on their region. It was concluded that the

mathematics literacy levels of students in almost all regions were below the international level. Regarding school types, the mathematical levels of the students from private high schools, Anatolian high schools and science high schools were found to be lower than those of other school types.

Yılmaz and Aztekin (2012) found that the mathematics literacy achievement of students was determined by sex; school population; teacher–student ratio; the economic, social and cultural level of the school (ESKD); and by the social and cultural level (ESKD), class, and economic factors of the students. According to the study, the number of mathematics teachers and the adequacy of educational materials did not significantly effect the average scores of schools. In fact, the average mathematics literacy scores of schools were found to decrease as the student–teacher ratio and the school population increased.

Özer and Özberk (2011) used the PISA 2009 Turkish data set in their study and observed that mathematics achievement varied depending on region, school type, and sex. It was concluded that the difference in mathematics literacy was in favour of boys.

Özer and Anıl (2011) used the PISA 2006 Turkish data to determine factors affecting the mathematics and science achievement of students. They found that the most important predictor of mathematics achievement was the time dedicated to learning mathematics. It was determined that the students' knowledge of computers and computer hardware also had a positive effect on their mathematics achievement. Student education material was found to have no effect on mathematics achievement.

In a study of the Trends in International Mathematics and Science Study 2011 Turkish sample, Aşkın and Gökalp (2013) attempted to determine the effect of some factors (enjoying learning, appraisal of learning, confidence in mathematics, being bullied at school, occupying oneself with mathematics, home education resources) and the correct classification ratio using both the logistic regression and artificial neural network methods. According to the results of the study, it was concluded that the best predictor of mathematics achievement is confidence in maths, that the correct classification ratio according to the logistic regression method is 78.5% and that the correct classification ratio according to the artificial neural network method is 78.6%.

Purpose and Significance of the Study

The fact that the students of Turkey have performed lower than the desired level in all literacy aspects across all PISA tests has been highlighted by many researchers (Altun, Aydın, Akkaya & Uzel, 2012; Bindak, 2009; Howard, Fleischman, Hopstock, Pelczar & Shelley, 2010; OECD, 2013a, 2013b;Özer & Anıl, 2011; Şirin & Vatanartıran, 2014). Although there are many studies that attempt to determine factors affecting literacy levels in PISA tests, the on-going problems, particularly related to mathematics literacy in Turkey, have caused many researchers to become involved.

The objective of this study is to examine the mathematics literacy levels of the students who constituted the Turkish sample for PISA 2012 with respect to some sociologic and socioeconomic factors, to attempt to reveal the reasons behind the low performance of Turkey in the PISA 2012 mathematics field, and to develop proposals for solutions. The implicit objective of the study is to demonstrate the usability in the education sciences field of the probit regression, which is generally used in health sciences, and to encourage researchers to use the probit regression in works related to education sciences.

Research Questions

To what degree do student factors such as having a study room, sex, preparing for exams, doing homework on time, interest in mathematics, enjoying mathematics, and mathematics related reading predict mathematics literacy?

What is the classification success level of the probit regression model when using dependent

and independent variables?

Methodology

Research Design

The study is a relational one as it attempts to determine the effect of some sociocultural and socioeconomic variables, selected as predictive variables, to classify the possibility of each Turkish participant in PISA 2012 being successful and unsuccessful.

Participants

A student needs to have received a minimum of seven years of education and be 15 years old in order to participate in the PISA test. The age of 15 years is recognised by PISA as the onset of adulthood as students of 15 years old are about to reach the end of the compulsory education period in most countries (Şirin & Vatanartıran, 2014). In 2012, 4,848 students in the 15-year-old age group from 170 schools around Turkey participated in the PISA test. The majority of the students (65.5%) participating were in the 10th grade. The target population of the study consisted of the students who participated in the PISA 2012 test. The sample of the study consisted of the 4,848 students from 170 schools representing Turkey in the test.

Dependent and Independent Variables

PISA estimates academic literacy in mathematics in terms of plausible values (PVMATH). Averages of PVMATH score types or any PVMATH scores can be used as alternative achievement criteria in studies carried out with respect to PISA (Micklewright & Georgina, 2004). For this study, PVMATH score types and the correlation between the averages of these scores were examined separately and it was observed that four correlations were above 0.90. It was decided to use the average score (449) as the cut-off score and individuals with scores below this were coded as unsuccessful (0) while those with scores equal to or greater than the cut-off score were coded as successful (1) and used in this study as the dependent variable. Among the independent variables, sex (0=*girl*, 1=*boy*) and owning a room (0 = *owning*, 1 = *not owning*) were coded with two categories. The remaining independent variables were 4-point Likert items (1=*strongly agree*, 2=*agree*, 3=*disagree*, 4=*strongly disagree*).

Data Analysis

Within the scope of the study, probit regression analysis was used to determine the effect of some sociocultural and socioeconomic predictive variableson the students participating in PISA 2012 being successful or unsuccessful. Probit regression is a type of analysis that is used to reveal the predictor–predicted relationship when the dependent or independent variables have two categories. While the dependent variable selected for probit regression has to have two categories, the type of independent variable is not important. If an attempt is made to explain one or more dependent variables with two categories using the linear regression method, the linearity assumption is breached and some mathematical transformations are used to linearise the relationship between the dependent and independent variables. Probit regression is a type of analysis used in these cases. The advantages of probit regression are that it is one of the qualitative preference models; normal probability density function is used more in both theory and practice and cumulative normal distribution function is used in calculation (Agresti, 2007; Cebeci, 2012; Tabachnick &Fidell, 2014).

Before conducting probit regression analysis, the assumptions on probit regression were tested. First, a lost data analysis was conducted. The amount of missing data for each of the independent fields other than sex and havinga study room was more than 5%. Garson (2008) states that it is not a problem to assign missing data in the event of having more than 5% missing data with respect to broad samples. The study included more than 5% missing data, mostly independent data, and therefore the data with the highest frequency was assigned as the missing data for each independent variable (Magnani, 2004; Royston, 2004).

Another assumption of probit regression is about there being a multicollinearity problem

between independent variables. The relationships between independent variables within an analysis should not be too strong. If there are very strong relationships between independent variables, there may be incorrect interpretations regarding the regression equation to be set. One of the most frequently used methods to determine multicollinearity is to control the variance inflation factor (VFI). If VFI values are greater than five or 10, then one can talk about multicollinearity (Tabachnick&Fidell, 2014). The VFI of all independent variables in the study was less than five (VIF on sex: 1,020; VIF on having a study room: 1,005; VIF on preparing for exams: 1,432; VIF on doing homework on time: 1,416; VIF on interest in mathematics: 1,982; VIF on enjoying mathematics: 1,764; VIF on enjoying mathematics reading: 1,796.

Findings and Results

Chi-square test is a goodness of fit test. Low values on a chi-square test show that the set model conforms with the observed structure while high values ona chi-square test show nonconformance of the model with the observed structure. As chi-square values are summation statistics, an increase in the number of variables in the set model also increases the chi-square statistic. When the chi-square statistic is high, a chi-square/degree of freedom equation is used. If the relative chi-square statistic is less than five, the goodness of fit of the model is adequate, and when it is less than three, it can be said that the model has a very good fit (Byrne, 1988). This study observed relative chi-square statistics in regard to the model representation of theoretical data (4850,56/4840,56). As the relative chi-square statistic is less than three, the Ho hypothesis of the first hypothesis test set within the scope of the study was accepted (the theoretical model represents the data well).

Table 1. *Statistics on Independent Variables Included in the Model*

	(B)Estimate	Standard Error	Wald Statistics	*p*
Invariant	-0,432342	0,079321	29,7087	0,000000
X1	-0,159234	0,037339	18,1865	0,000020
X2	0,454361	0,040843	123,7557	0,000000
X3	0,332112	0,035497	87,5333	0,000000
X4	-0,299079	0,033083	81,7269	0,000000
X5	-0,057459	0,035129	2,6753	0,101915
X6	0,154618	0,029977	26,6046	0,000000
X7	0,098807	0,031863	9,6164	0,001929

$p<.05$

*Note.*Abbreviations.X1: sex, X2: havinga study room, X3: preparingfor mathematics exams, X4: doing homework on time X5: interest in mathematics, X6: enjoying mathematics, X7: enjoying mathematics reading.

Table 1 includes statistics related to independent variables within the probit regression model. Probit models use the Wald criteria which tests the significance of the parameters of the independent variables in the model. The model has one parameter for each independent variable. Agresti (2007) and Polit (1996) have stated that the Wald value is used to test whether the parameters can be considered to be related when independent variables are zero. The Wald test can also be considered as a significant test of the regression coefficient (Field, 2009). If the Wald test

related to the independent variable is significant, it can be concluded that the parameter related to the independent variable is not zero, that the independent variable contributes significantly to the model and that the model should include the independent variable. If the Wald test related to the independent variable is not significant, it is up the researcher to include the independent variable in the model (Altman, 1991). While the Wald value has to be more than two to be regarded as significant, the probability value decreases as the Wald value increases. The Wald test should only be used in broad samples. If the sample is small the likelihood ratio test used as an alternative to the Wald test provides better results (Agresti, 2007). When we examined the Wald statistics related to the independent variables included in Table 1, all of the independent variables other than the one related to enjoying mathematics had a significant effect on the dependent variable.

When we examined the regression coefficients in Table 1 that show the effect of the independent variables on the dependent variable, we concluded that the independent variables other than the one related to interest in mathematics had a significant effect on the dependent variable. The interaction of the dependent variable with the independent variables other than the one related to doing homework on time was positive.

Table 2. *The Ratio of the Observations Correctly Predicted according to the Probit Regression Analysis*

	Expected (Unsuccessful)	Expected (Successf	Percentage of Correct Prediction
Observed			
Unsuccessful	2144	533	80,08965
Successful	1482	689	31,73653
General Classification Ratio			58.44

When we studied Table 2, the intersection of line 1 and column 1 indicated the number of unsuccessful (0) individuals who were classified by the program as unsuccessful (0). Of the 2677 participants, 2144 were classified correctly in the study and the classification percentage was given as 80.08%. The intersection of line 1 and column 2 indicates the number of unsuccessful individuals (0) who were classified by the program as successful (1). Of the 2677 participants, 533 were classified as successful despite being unsuccessful. Accordingly, the program had incorrect classifications for 20% of the individuals. The general correct classification ratio of the model set for probit regression is 58.4%. That is, by using the independent variables included in the study, it is possible to have a 58.4% correct prediction about whether the mathematics literacy score of the student will be less than the cut-off score or not.

Conclusion and Recommendations

According to the results, Turkey's PISA 2012 mathematics literacy scores varied with respect to sex, in favour of the girls. Based on this result, we can conclude that girls are more successful in maths than boys. Çiftçi (2006) examined some factors affecting Turkish student achievement in the PISA 2003 mathematics subtest results and stated that sex differences were significant only for the students living in the Blacksea region and that the PISA 2003 test was in of favour girls with respect to achievement. According to an OECD (2004) report, mathematics literacy in Ireland was in favour of girls when the PISA 2003 results were taken into consideration. There are other studies indicating that girls generally have better mathematic achievement than boys (Alkhateeb; 2001; Baya'a, 1990; Ma, 1995).

According to the results of the study, there is a negative relationship between doing

homework on time and mathematics achievement. According to the TIMMS 2011 National Mathematics and Science Report of MEB (2014) for the eighth grade students, those who spent more time on mathematics were more successful than those who spent the most time on mathematics homework. Meier and Schmeck (1985) stated in their study that routine practises given to students creates serious boredom and eventually leads to burnout syndrome. They concluded that in the long-term the physical and psychological fatigue of students as a result of excessive homework and having to do homework on time createda feeling of boredom regarding this work, led to the homework being seen as meaningless and caused a drop in achievement. The negative relationship seen in our study may have been caused by the individual qualities of the students in the sample or because of the fact that the survey used in the PISA test was wrongly adapted during interpretation to Turkish (in Turkey, 1 refers to *strongly disagree* while it refers to *strongly agree* in PISA surveys). Asil and Gelbal (2012) examined the intercultural and interlingual equivalence of the survey applied under PISA 2006 by comparing the samples of the United States of America, Australia, New Zealand, and Turkey and concluded that the items of the survey demonstrated bias based on translation and adaptation rather than cultural differences.

According to the results of the study, there is no statistically significant relationship between an interest in mathematics and mathematics achievement. According to the PISA 2012 National Preliminary Report issued by MEB (2013), 48% of the students in Turkey look forward to mathematics lessons. However, while this showed that the students in Turkey have a positive interest in mathematics lessons, it was concluded that one of the basic problems is that this positive interest was not reflected in academic achievement. According to the Turkey PISA 2012 study conducted by Eğitim Reformu Girişimi (2014), Turkish students' interest in and sympathy towards mathematics was above the average of OECD countries. In addition to interest in mathematics, almost half of the students in Turkey (48%) stated that they looked forward to mathematics lessons. In a study by Akarsu (2009), it was concluded that the effect of interest in mathematics on mathematics achievement was not statistically significant. Doğan and Barış (2010) attempted to determine the level of prediction of variables such as attitude, value, and self-efficacy for mathematics achievement and it was concluded that the attitude scores in the TIMSS surveys measuring emotional dimensions had no significant effect on the TIMSS1999 mathematics scores. Çam (2014) administereda shortened version of the PISA 2009 mathematics test to 120 students in ninth grade to determine the factors affecting their PISA mathematics achievement and concluded that positive or negative attitude towards mathematics had no significant effect on mathematics achievement.

According to the results of the study; there is a positive relationship between enjoying mathematics reading and mathematics achievement. According to a report of the Turkish PISA 2012 done by ERG (2014), two types of motivation were measured in the PISA 2012 survey: interior and goal oriented. ERG stated that interior motivation is based on the enjoyment students have for mathematics reading. It was found that 56% of the students stated that they enjoyed mathematics reading; this dropped to 34% in OECD countries in general and interior motivation in the Turkish students was higher than average despite their mathematics literacy performance being lower than all the other countries compared.

The study indicates that mathematics achievement is positively correlated with having a study room, preparing for examinations, enjoying mathematics, and enjoying mathematics reading. These results were expected by the researchers and are somewhat interrelated.

According to the results of the study, the reasons for the lack of some expected relationships include: the sample structure of PISA (some countries only include students with high skills or achievement, while some countries include students with disabilities or learning difficulties); achievement differences (national or international variance differences do not always reveal the achievement and underachievement of students); and language and culture (PISA is prepared in English and French, therefore there are perception differences depending on which test is used by the participating countries for translation and the difficulty level of the questions may change) (Tedmem, 2014). It can be considered that the PISA method also plays a role in results. The Rasch

model is used in the analysis of PISA data. Due to the structure of the Rasch model (validity), all questions in the test should have the same difficulty level. Kreiner (2011) concluded that PISA participants don't answer questions in all fields of mathematics, science and literacy and that the system allocates students possible values and uses the general average to determine country ranking; this ranking is done by using these possible values and therefore country rankings and generalisations are not valid.

According to the results of the study, whether the mathematics literacy score of students will be below the cut-off score can be predicted to 58.4% accuracy by using the independent variables of the model. Gürsakal (2012) examined the factors affecting student achievement levels through regression analysis of the PISA 2009 Turkish sample and concluded that the correct classification percentage of the model with respect to mathematics literacy was 67.1%. Özer and Doğan (2012) used the logistic regression analysis to determine variables that are effective in predicting the reading skills of primary school eighth grade students; they administered the achievement test and a student survey measuring reading literacy skills within the scope of the 2009 PISA test to 3004 students and concluded that the correct classification ratio of the model created by logistic regression was 70.6%. This value may be considered to be relatively sufficient. Taking into consideration the relevant researches, it can be said that the classification percentage observed as a result of this study is relatively sufficient.

According to the results of the study, there is a negative interaction between doing homework on time and mathematics achievement. This situation needs to be seriously considered within our education system. When teachers assign homework to students, they need to give prominence to the quality of the homework, not the quantity. At the same time, teachers should assign homework based on learning rather than repetition and preparation. According to the results of the study, it is concluded that the achievement of girls is generally higher than boys. Teachers have a great role to play in balancing the mathematics achievements of boys and girls. This may involve creating a discussion environment in the classroom. Classroom discussions covering the learning styles, suggestions and ideas of students should be supported. Equal participation of boys and girls in these discussions should be ensured. Particularly, boys should be encouraged to express their ideas about mathematics and mathematics teaching and the teachers should always take these ideas into consideration.

According to the results of the study, it is concluded that there is no significant relationship between interest in mathematics and mathematics achievement. Seminars about fostering mathematics interest could be organised to establish a positive relationship between mathematics interest and mathematics achievement. These seminars could be organised to line up with basic teacher objectives like enjoying mathematics, preferring mathematics, and interior motivation. These mathematics interest development programs should remove the negative conditions that may exist between sex roles and mathematics interest. It should be noted that mathematics related beliefs are effective in creating mathematics interest. Therefore, a change needs to be made in the attitudes of parents and students towards mathematics. In addition, courses may be organised in the fields of mathematics teaching and classroom management for teachers who want to develop the mathematics interests of students.

According to the results of the study, itis concluded that students with a study room are generally more successful in mathematics than students who have not a study room. It is very important for students to have a study room in order to start studying easily, not be distracted, not waste time, and to carry out healthy study habits. Parents should be made aware of the necessity of study rooms and this should be supported by teachers.

According to the results of the study, there was a positive relationship between enjoying mathematics reading and mathematics achievement. In this context, teachers should organise mathematics reading activities in the classroom. Teachers should also inform families of this correlation and encourage them to support their children to see mathematics not only as a subject but

also as practical skills that can be frequently used in real life.

According to the results of the study, it is concluded that there is positive relationship between exam preparation and mathematics achievement. Study time and studying methods have a positive effect on the mathematics achievement of students. Routine repetition should be ensured to safeguard against the possiblity of students forgetting the learned subjects. Methods and techniques of study are equally as important as the review of subjects. Teachers and parents should inform the students about methods and technique that provide for effective learning and ensure that they are aware of these factors themselves.

The sample of this study consisted of Turkish students. Similar studies can be repeated in different countries.

This study examined the PISA achievement prediction status of sociocultural and socioeconomic countries involved in PISA testing. There may be studies about how the same variables can predict achievement levels in national examinations and in schools of the students participating in PISA.

The same study can be done by using a different regression method with two categories of independent variable and results can be compared with respect to methods.

Studies on similar subjects can be conducted by using different sociocultural and socioeconomic variables.

Similar studies can be conducted in order to determine the variables that affect the science literacy or reading skills.

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