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Analysis of Maths Literacy Performances of Students with Hierarchical Linear Modeling (HLM): The Case of PISA 2012 Turkey

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Abstract

The objective of this study is to determine whether there is a difference among the mathematics literacy performances of students according to the student and school levels in the Turkey sample by using the data of the PISA 2012 test which is one of the large scale examinations. It is also an objective of the study to determine which variables have a significant effect on mathematics literacy in this two-level structure, i.e. student level and school level. The sample of the study consists of 4848 Turkish students from 170 schools participated the PISA 2012 test. Hierarchical Linear Model (HLM) was used in the analysis of the data. The variables within the study were dealt with at 2 levels, namely the school level and the student level. According to the findings obtained by the study, the effect of student level variables like gender, school type, motivation, self-efficacy, attitude, behaviour control, causes of failure, work discipline, mother education, father education, computer possession, age and tablet possession on the mathematics literacy at school was found to be statistically significant. On the other hand, it was determined that the school level variables like school revenues, number of mathematics teachers, number of students, teacher-student ratio and the morale of teachers have a significant effect on predicting the mathematics literacy. After the study, it was determined that nearly 63,17% of the difference between the mathematics literacy points of the students was caused by the difference between the schools.

Keywords

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Introduction

There are large scale examinations applied by several organizations throughout the world that compare the international achievement of students and allow countries to review their education policies (Anderson, Lin, Treagust, & Yore, 2007; Knodel, Martens, & Niemann, 2013; Çobanoğlu & Kasapoğlu, 2010). These large scale examinations assess the student achievement and include detailed qualities on the concept of literacy (Sahlberg, 2011; Aşıcı, Baysal, & Erkan, 2014). In addition, the results of this type of large scale examinations provide information on the student achievement and level. Such large scale examinations also allow studies about the relations between the student achievement, the qualities about the history, attitude, school and living place of students (Akyüz & Pala, 2010; Anderson, 2012; Aydın, Sarıer, & Uysal, 2012).

PISA is one of the large scale examinations that are applied internationally and it is held every three years by the Organisation for Economic Co-operation and Development (OECD) (Ministry of National Education [MEB], 2013; Sarıer, 2010). The PISA test is about the of 15 years old students's success about how they use their knowledge and skills in mathematics literacy, reading skills and problem solving in overcoming the difficulties they face in real life (Türkan, Üner, & Alcı, 2015; OECD, 2013a). The PISA test provides the assessment of whether the students have high level of cognitive skills and the production of indicators based on the obtained results to create polices in line with the objectives. The test also includes surveys to the students, parents and school administrators and reviews the sources of achievement or failure of students (OECD, 2008; Anıl, 2009).

Mathematics literacy has been constructed on an important structure for the PISA test. This structure is based on the expression of mathematics competencies of students. In the PISA test, mathematics literacy refers to the ability of students to interpret their knowledge and skills and to use them in different conditions (Altun & Akkaya, 2014; Cosgrove, Perkins, Shiel, Fish, & Mcguinnes, 2012; Koğar, 2015). The PISA test presents real life problems to the students with respect to mathematics literacy. Students need to use their mathematical skills when solving the real life problems presented to them. Mathematical qualifications require top level cognitive skills like deduction, model building, revealing the problem condition and solving the problem (OECD, 2008, 2012). Six different student levels were defined for the PISA mathematics literacy taking into consideration the ability of students to use top level cognitive skills (MEB, 2007, 2010, 2013).

Level 1 (358-419 points): The students at this level can answer questions where all relevant information is present and the questions are clearly defined.

Level 2 (420-481 points): The students at this level students are considered to be sufficient in processes that require conclusion from one or more propositions. They can employ basic algorithms and formulae.

Level 3 (482-543 points): The students at this level can execute clearly described procedures, including those that require sequential decisions.

Level 4 (544-605 points): The students at this level can carry out actions by using pre-defined models when there are complex and concrete problem situations that may involve constraints and assumptions.

Level 5 (606-667 points): The students at this level can develop and work with models for complex situations. They can identify constraints and specify assumptions regarding the models they develop. They can select, compare, and evaluate different strategies when they face complex problems.

Level 6 (668-1000 points): The students at this level can conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations. They can develop new and different approaches and strategies for the solution of the novel problems.

In addition to this classification, different studies in recent years revealed a different classification than the existing ones by directing mathematics literacy questions to secondary school students. A study by Altun and Bozkurt (2017) determined that mathematics literacy has a 6 dimensional structure consisting of (i) algorithmic operation, (ii) command of rich mathematical content, (iii) mathematical deduction, (iv) mathematical suggestion development and/or interpretation of developed suggestions, (v) understanding mathematical equivalent of life situation and (vi) understanding life equivalent of mathematics language. Turkey has been regularly participating since 2003 in the PISA project that started in 2000. According to the PISA results, Turkey is behind the OECD countries in all tests of mathematics literacy which is evaluated in six levels (Anıl, 2009; OECD, 2013b). When the PISA 2003 and PISA 2012 results are studied, we see that Turkey's ratio for students at the first level and below in mathematics decreases. The reports of the PISA test clearly indicate how low is the level of Turkey for PISA mathematics literacy (OECD, 2008, 2012, 2013a, 2013b, Türk Sanayicileri ve İş Adamları Derneği [TÜSİAD], 2014).

Table 1. Distribution of PISA 2003-2012 Students according to Proficiency Levels of Mathematics Field (TÜSİAD, 2014)

	2003	2006	2009	2012	2003	2006	2009	2012	2003	2006	2009	2012
	Under 1st level				**1st level**				**2nd level**			
1st Country	3,9	4	3	0,8	6,5	8	6,8	2,9	13,9	14	13,1	7,5
OECD	8,2	7,7	8	8	13,2	13,6	14	15	21,1	21,9	22	22,5
Turkey	**27,7**	**24,0**	**17,7**	**15,5**	**24,6**	**28,1**	**24,5**	**26,5**	**22,1**	**24,3**	**25,2**	**25,5**
	3rd level				**4th level**				**5th level**			
1st Country	20	19	18,7	13,1	25	22	22,8	20,5	20	20	20	24,6
OECD	23,7	24,3	24,3	23,7	19,1	19,1	18,9	18,2	10,6	10	9,6	9,3
Turkey	**13,5**	**12,8**	**17,4**	**16,5**	**6,8**	**6,7**	**9,6**	**10,1**	**3,1**	**3**	**4,4**	**4,7**
	6th level											
1st Country	10,5	11,8	15,6	30,8								
OECD	4	3,3	3,1	3,3								
Turkey	**2,4**	**1,2**	**1,3**	**1,2**								

When we reviewed the literature, we found studies on the factors affecting the mathematics literacy of the students in the age group of 15. There are various studies in the literature that deal with the influence on the mathematics literacy of the students in the age group of 15 by the region and school type (Berberoğlu & Kalender, 2005; Berberoğlu, 2007), by the time dedicated to learn mathematics (Özer & Anıl, 2011; Saidel & Shavelson, 2007; Anderson, 1995), by gender (Özer & Özberk, 2011; Ovayolu, 2010; Stacey, 2011) and by the economic and cultural conditions of the individuals (Yılmaz, 2009; Stacey, 2011). In addition, there are studies in the literature (Akyüz, 2006; Güzel, 2006; Shin, Lee, & Kim, 2009) that determine the multilevel factors related to the mathematics literacy of the students by considering the variables of student level and school level.

The aim of this research is to determine whether the mathematical literacy performance of the students vary considering the traits such as gender, cognitive strategies, personal attitudes, self conceptions, dimension, school environment and academical focus and to reveal which variable has a significant effect on two regular forms. An analytical approach is adopted in this research which contains students and school variables together and tries to explain the relations through modeling of multilevel mathematical data. In addition, considering the analytical approach in this research, in one sense PISA 2012 has an importance in summarizing Turkeys results in a relational sense and utilization of research opportunities. Furthermore this research is has a theoretical importance for strengthening mathematical literacy and better explanation of the situation of relational patterns intertwine with each other. The affective traits covered by the study are motivation, self-efficacy, attitude and work discipline. Motivation is considered to be one of the most important factors for a better academic performance (OECD, 2013b). There are two types of motivation in PISA 2012, i.e. instrumental and internal. Both structures are based on Self-determination theory and expectancy value theory (Ryan & Deci, 2009; Wigfield & Eccles, 2000). Instrumental motivation defines mathematics to be a learning instrument as they find mathematics to be useful for themselves and for their future careers (Eccles & Wigfield, 2002). Internal motivation is matched with the happiness gained from the activity (OECD, 2013b). Within the scope of the study, articles related to instrumental motivation were used. Bandura (1997) defines self-efficacy as the capacity of an individual to fulfil the procedures of an action to be carried out. The mathematics self-efficacy concept based on the definition of Bandura (1997) is defined to be the capacity of individuals to solve certain mathematical problems, fulfilling mathematical tasks or fulfilling the success skills in mathematics related subjects (OECD, 2013b). There are studies in the relevant literature that demonstrate a positive relation between the self-efficacy beliefs and academic performance (Skaalvik & Skaalvik, 2004; Martin & Marsh, 2006; Wigfield, Eccles, Schiefele, Roeser, & Kean, 2006; Denissen, Zarrett, & Eccles, 2007). Mathematics self-efficacy is one of the strongest estimators of mathematics achievement (Stevens, Olivarez, & Hamman, 2006; Bouffard, Boileau, & Vezeau, 2000). PISA 2012 made mathematics self-efficacy operational within the scope of the levels of the students to believe in their own skills to fulfil certain mathematical tasks. In line with these information, articles related to mathematics self-efficacy were used. Attitude can be defined as the "sum of the inclinations and emotions, prejudices, ideas, fears, threats and opinions of a person on a subject" (Thurstone, 1928). Attitudes are integral to human characteristics and includes inclinations and dispositions that guide the behaviours of individuals. There are several studies and researches in the literature to find the factors that affect the mathematics achievement of students (Papanastasiou, 2000; Nicolaidou & Philippou, 2003; Bramlett & Herron, 2009; Mohd, Mahmood, & İsmail, 2011). Among these factors, students' "attitude towards mathematics" is an important factor that is consistently studied. There are several studies to reveal attitudes of students towards mathematics (Bramlett & Herron, 2009; Köğce, Yıldız, Aydın, & Altındağ, 2009; Maat & Zakaria, 2010; Tahar, Ismail, Zamani, & Adnan, 2010; Tezer & Karasel, 2010). The present study used the items in the PISA 2012 student survey regarding the attitude towards mathematics.

Determining consistent relationships between students and school characteristics and mathematical literacy has significant importance both theoretically and practically. These characteristics contains student characteristics such as gender, cognitive strategies, personal attitudes, self conceptions, dimension, school environment and academical focus. It is estimated that it could enable the understanding the level of accessibility and could improve the efficiency of schools in the context of related characteristics via relations with the research and politics. It is estimated that findings obtained from this work can shed light on the involvement of emotional components for the understanding of mathematics by teachers and students in educational or intervention programs in the sense of building policies for classrooms. It was attempted to find answers to the following research questions in line with the objective set:

Is the model set for the variables measured at the student and school levels using the PISA 2012 data significant?

- Which of the variables measured at student level predict significantly the mathematics literacy points of the students?
- Which of the variables measured at school level predict significantly the mathematics literacy points of the students?
- What are ratios of variables with a significant effect on the student and school level to describe the mathematics literacy points?

The works conducted on PISA provide data and vision in sense of making and improving education policies nearly all over the world. For this reason the audience addressed by this work is composed of ministries of educations, academicians, think tanks, educators and media.

Method

Study Design

This study focuses on the determination of the variables that predict the mathematics literacy levels at the first and second stage in the PISA test which has a two stage structure i.e. student level and school level. The study attempts to reveal the relation between the mathematics literacy and the qualities of students and schools, therefore, the type of the study is determined to be compatible with the relational screening model (Fraenkel, Wallen, & Hyun, 2012). The study attempts to determine the effects of the independent variables on the dependent variable, therefore, the study was conducted in compliance with the comparative studies among relation survey models (Karasar, 2005). (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel; 2016; Karasar, 2002).

Population and Sample

The population of this study consists of the Turkish students in the age group of 15 participating in the PISA 2012 test. The sample of the study consists of 4848 students from 170 schools where PISA was applied in 2012 (OECD, 2012). 48,9% of the students are girls and 51,1% of them are boys. The data which makes the sample of the study was obtained from the web address https://pisa2012.acer.edu.au/downloads.php which announced the results of the PISA test. The researchers converted the *student questionnaire* and *school questionnaire* files on the page tin the SPPS program by the command recommended in the PISA official page and made them ready for analysis.

Data Collection Instrument

This study deals with the PISA 2012 data and therefore no data collection instrument was prepared. The variables used in the student level and school level analysis were determined on the basis of literature. The variables used in the student level are the gender of the students, total interest level, total motivation level, total self-sufficiency level, total attitude level, behaviour control level, reasons of failure, work discipline, mathematics related behaviours, student-teacher relation, mother education level, father education level, possession of computer, number of absent hours, rate of participation in mathematics courses, age, social-cultural and economic index and possession of tablets at school. The school level variations are the budget type of the school, location, options of different schools in the region, school type, assistance from the state, own income of the school, number of boys at school, number of girls, number of total teachers, number of mathematics teachers, number of total students, number of computers at school, number of computers with internet access, school index, source index, independency of the school, teacher/student ratio, moral level of teachers, lack of teachers and classroom size. All items in the subscales of the student level affective qualities are scored in the 4-item Likert scale like strongly agree=1, agree=2, disagree=3 and strongly disagree. The school level variables were divided into four categories, i.e. 1=primary, 2=general secondary, 3=vocational and technical secondary and 4=police education. The distribution of the students studying at these schools are as follows: 12,9% primary school, 51,2% general secondary, 34,7% vocational and technical secondary, 1,2%=police education.

Lost Data

Although there wasn't any lost data at the school level from the data files addressed in the study, it was reported that there was lost data problem at the student level. When we looked at the responses of the students, it was determined that the lost data ratio was lower than 5%. Because the missing data was smaller than 5%, the randomness was analyzed by looking at the correlation between the variables suggested by Kalaycı (2004). According to the results, it was iobserved that the missing data showed a randomized distribution because there was a low level correlation ($r=.14$, $p>.05$) between the missing data (Allison, 2003; Little, 1988). Therefore, centralization methods were applied for the lost data. There is no absolutely correct choice for the centralization methods used in the models while the choice of method to be applied varies depending on the objective of the researcher (Kreft, 1995).

Data Analysis

A hierarchical linear model was used for the analysis of the relevant data set under the study. The hierarchical linear model is a complex form of the least squares method. The variances of the dependent variables can be calculated when the independent variables were divided into hierarchical levels by using the hierarchical linear model (Raudenbush & Bryk, 1992, 2002; Lindley & Smith, 1972). This means, the variance of the dependent variables can be calculated itself without any independent variables. HLM divides the total variance of the dependent variables into two components: between level and within lelvel (Hox, 2002).

Before developing the hierarchical linear model, the data sets were used to be analysed by using linear regression. However, linear regression was inadequate in the analysis of the data set with a hierarchical structure as the use of linear regression ignored common variance. Multilevel data can be degraded to a single level by the method of aggregation of variances belonging to sublevel in the high level or disaggregation of variances belonging to high level in the sub level (De Leeuw & Kreft, 1986) However, the alterations among the groups are ignored because the group differences in these approaches (Osborne, 2000). Because of this reason, in case the variability between the groups are important, it will dominate more. With the aggregation of high level variables in level 1, the common variance cannot be explained, and the hypothesis of error independence is violated (Woltman, Feldstain, MacKay, & Rocchi, 2012).

The algorithm that facilitates the estimation of the covariance values on unbalanced data emerged in the beginning of 1980s. Development of such an algorithm mainstreamed the use of hierarchical linear model in data analysis (Dempster, Rubin, & Tsutakawa, 1981; Smith, 1973; Osborne, 2000). The usage area of the model became more widespread thanks to the contribution of the linear model to the theoretical statistics.

The variables addressed within the scope of the study are considered in 2 levels, i.e. student level and school level (Lee, 2000). As it was attempted to predict the mathematics literacy levels of the students by the help of variables used at the student level and school level, the average of the PVMATH points was used as the result variable (Shera, 2014). The analyses were conducted with the HLM 7 program as the data had a hierarchical structure at the school and student levels. The different data files including the student level and school level variables were transferred separately to the HLM program and the link between the levels was assured by the variable of school ID.

The HLM program doesn’t allow analysis with the lost data and therefore the median based lost value assignment methods were used for the categorical data and average based lost value assignment methods were used for the continuous variables (Cohen, Cohen, West, & Aiken, 2002). Harrell (2001) states that the value assigning methods based on median are the best predicting method in data set in which missing data range completely randomly. Similarly, methods based on median are stated as one of the best predicting methods in the website, https://www.ctspedia.org/wiki/pub/CTSpedia//StoddardCh5S9/GSC5S9_missing_data.doc The data are cantered in the analyses to reduce the high correlation between the level 1 and level 2 variables and the cross level interactions (Raudenbush & Bryk, 2002). The variables in Level 1 are cantered around the group mean while the variables in Level 2 are cantered around the grand mean. No centering is done in categorical variables (Garson, 2013).

Results and Interpretation

The total variance in the student points was divided into two level namely student level (level1) and school level (level2) in order to determine whether there is a significant difference between the mathematics literacy points of the students who took the PISA 2012 test. In addition, it is aimed to find out which variables are causing this difference. The hierarchical linear model is initially called as the random effects model or the null model in the literature and it tests whether the model that allows the random distribution of the result variable between the schools or, in other words, the HLM is necessary or not (Hox, 2002; Woltman et al., 2012). The following is the two-level regression model that is created on the assumption that the mathematics literacy points which are accepted to be result variable don't vary between schools and their values are kept constant:

$$Y_{ij}= \beta_{0j}+ r_{ij} \ (level1)$$

$$\beta_{0j} = \gamma_{00}+ u_{0j} \ (level2)$$

In this model, Y_{ij} indicates the dependent variable for the individual *i* in the group *j*, or in other words, the mathematics literacy point which is defined as the result variable of the student *i* in the school *j*. β_{0j} indicates the mean dependent variable in group *j* and r_{ij} indicates the random effect related to the individual *i* in the group *j* (Lin, Tzou, Shyu, Hung, & Huang, 2006). γ_{00} in the second level is the he average of the averages of *j* schools (general mathematics literacy mean) and the u_{0j} is the random effect of *j* groups (Anderson, 2012). Table 2 includes the information on the significance of the HLM analysis for the PISA 2012 data.

Table 2. Estimation of the fixed effects of the one-way ANOVA model with random effect

Fixed Effects	**Coefficients**	**Standard error**	***t*-ratio**	**s.d.**	***p.***
For the invariant β_{0j},					
Average School mean, γ_{00}	439,17	5,72	76,78	169	0.000

When the Table 2 is reviewed, it was concluded that the school averages were varied significantly from zero, and so the averages of the schools within the context of this research differed from each other significantly (t=76,78, p<.001). In addition to that, the real value of the mathematics literacy points in the Turkey sample was found to be between 439,17 ± 1,96 (5,72) by a possibility of 95% and varied between 427,98 and 450,36. Table 3 includes the information on the last estimation of the random effects in the model.

Table 3. Estimation of Variance Components of the One Way ANOVA Model with Random Effect

Random Effects	**Standard Deviation**	**Variance Components**	**s.d.**	χ^2	***p.***
School Average, u_{0j}	73,46	5397,40	169	8752,63	0.000
Level-1 Effect, r_{ij}	56,09	3146,24			

When the Table 3 is examined, the variance of school means was estimated to be 5397,40 taking into consideration the general average in Turkey. The variance of the mathematics literacy points of the student was estimated to be 3146,24 within the framework of the school average at student level. The value range for the school averages is $439{,}14 \pm 1{,}96.(5397{,}40)^{1/2}$, or in other words, 95% percent of the school averages falls within the range of 295,14 to 583,13. According to this result, the mathematics literacy levels between the schools in the sample are within a broad range. The disclosed variance ratio index is obtained by comparing the τ_{00} estimations of the model for both levels in order to determine how much of the variance, called as intra-class correlations, between the mathematics literacy is caused by the difference between the schools (Hays, 1973; Hox, 1995). Accordingly, the disclosed variance value in β_{0j} is calculated by the following equation.

$$\rho = \frac{\sigma_{u0}^2}{\sigma_{u0}^2 + \sigma_e^2}$$

Accordingly, it was determined that the nearly 63,17% (5397,40/5397,40+3146,24) of the difference between the mathematics literacy points of the students. In the next stage, we obtained the model considered to be the first level and known to be the Random Coefficient Model (Raudenbush & Bryk, 2002). We believe that the first level model is similar to the simple linear regression model (Atar, 2010). In this model, which is included in Level 1, we intended to determine which independent variables have a significant effect on the mathematics literacy. Accordingly, the independent variables in this model are the gender of the students, total interest level, total motivation level, total self-efficacy level, total attitude level, behaviour control level, reasons of failure, work discipline, mathematics related behaviours, teacher-student relation, mother education level, father education level, possession of computers, number of absent hours, ratio of participation in mathematics courses, age, socio-cultural and economic index and possession of tablets at school. The method proposed by Garson (2013) was used to test the significance of the model created in Level-1. This model was used to test in the HLP program the significance of the hypothesis of the deviance value (53.435,81) obtained in the null model. Based on the result that there is a great reduction in the deviance value (52.774,57) obtained after the analysis and that the result of the variance-covariance components is significant (χ^2=660,42; p<0.001), it was concluded that the level 1 model is statistically significant. In addition, the significance of the model is evidenced by the fact that the obtained *residual component* value reduced from 3146,24 for the null model to the 2750,02 to the first level (Garson, 2013). Table 4 includes the results obtained on these variables which were determined by different researchers in the literature to have a significant effect on mathematics literacy.

Table 4. Estimation of Fixed Effects on the Random Coefficient Model in the First Level

Fixed Effects	**Coefficients**	**Standard Error**	***t*-ratio**	**s.d.**	***p.***
General Achievement Average, γ_{00}	397,95	20,53	19,38	169	0.000
Gender, γ_{10}	**19,87**	**1,79**	**11,07**	**4659**	**0.000**
School type, γ_{20}	**4,82**	**8,64**	**0,55**	**4659**	**0.577**
Interest level, γ_{30}	0,83	0,46	-1,78	4659	0.074
Motivation level, γ_{40}	**1,16**	**0,45**	**2,57**	**4659**	**0.010**
Self-efficacy level, γ_{50}	**3,78**	**0,26**	**14,45**	**4659**	**0.000**
Attitude level, γ_{60}	**2,22**	**0,24**	**8,93**	**4659**	**0.000**
Behaviour control level, γ_{70}	**1,08**	**0,39**	**2,74**	**4659**	**0.006**
Causes of failure, γ_{80}	**1,00**	**0,29**	**3,38**	**4659**	**0.001**
Work discipline, γ_{90}	**0,80**	**0,23**	**3,41**	**4659**	**0.001**
Maths related behaviour, γ_{100}	0,44	0,25	1,71	4659	0.087
Teacher-student relation, γ_{110}	0,17	0,33	0,52	4659	0.600
Mother education, γ_{120}	**1,92**	**0,82**	**2,33**	**4659**	**0.020**
Father education, γ_{130}	**-3,16**	**0,92**	**-3,44**	**4659**	**0.001**
Possession of computer, γ_{140}	**-10,38**	**2,02**	**-5,12**	**4659**	**0.000**
Absence, γ_{150}	0,33	0,94	0,35	4659	0.726
Part.in math. course, γ_{160}	1,29	0,89	1,44	4659	0.149
Age, γ_{170}	**5,58**	**2,76**	**2,02**	**4659**	**0.043**
SEK index, γ_{180}	1,57	1,32	1,18	4659	0.236
Tablet possession, γ_{190}	**8,04**	**1,72**	**4,66**	**4659**	**0.000**

When we look at the Table 4, we found that the effects of the variables of gender, school type, motivation, self-efficacy, attitude, behaviour control, causes of failure, work discipline, mother education, father education, computer possession, age and tablet possession are statistically significant ($p<0.01$). According to the model, the average of the boys is nearly 20 points above the average of the girls. In addition, a one-unit increase in the number of tables will cause an increase of 8,04 points in the mathematics literacy points, a one-unit increase in the age variable will cause an increase of 5,58 point in the mathematics literacy points and 1 unit variability between school types will cause 4,82 point variability in maths literacy. It was identified that the school types which are the sources of variability were coded in the data file as private schools and state school, and private schools has a stronger effect on maths literacy in comparison with state schools. However, a one-unit increase in the number of computers of the students will cause a decrease of 10,38 points in the mathematics literacy points. Moreover, the effect of the variables that are interest levels of the students (($t=-1.78$, $p>.05$), their behaviour related to maths ($t=1.71$, $p>.05$), the relationships bewtween students and teachers ($t=0.52$, $p>.05$), attendanding/not attending to the classes ($t=0.35$, $p>.05$), the situation of attending/not attending to the math courses apart from the class hours ($t=1.44$, $p>.05$), and socio-economic index ($t=1.18$, $p>.05$) on the maths literacy is not statistically significant. The 1 unit increase in the level of the self-efficacy of students will cause a 3,78 unit increase in their maths literacy in terms of affective characteristics. Similarly, it is seen that a 1 unit increase in the level of attitudes of students towards the course will cause a 2,22 unit increase in their level of maths literacy. Besides, although the effect of the variables ''behaviour control and study discipline '' on maths literacy is significant, regression coefficents determining effect level are 1,08 and 0,80. This can be interpreted that these variables do not have a strong effect on math literacy. The most interesting result is probably that 1 unit increase in the education level of students'fathers causes 3,16 point decrease in their maths literacy. Table 5 includes the estimation of the variance components on the Random Coefficients Model obtained for the variables that predict the mathematics literacy points at the student level.

Table 5. Estimation of the Variance Components on the Random Coefficient Model in the First Level

Random Effects	Standard Deviation	Variance Components	s.d.	χ^2	*p*
School Average, u_{0j}	74,29	5519,19	169	10257,35	0.000
Level-1 Effect, r_{ij}	52,43	2749,83			

When we look at the Table 5, the variance of the mathematics literacy points of the schools was estimated to be 5519,19 after the addition of level 1 variables to the model considering the general average in Turkey. In addition, when we add the student level variables to the model, it was determined that the mathematics literacy points varied between 359,97 and 435,93 by a 95% possibility. By the addition of the student level variables to the model, it was determined that 66,72% of the difference (5519,19/5519,19+2749,83) between the mathematics literacy was caused by the difference between schools. According to this result, it can be said that there is an increase of nearly 4% in the variance amount disclosed when the student level variables are added to the model. The r^2 values were calculated by the following equation in order to determine the effect size of the student level variables which were determined to have a significant effect on mathematics literacy (Woltman et al., 2012).

$$Pseudo\ R^2 = \frac{\sigma^2_{unconditional} - \sigma^2_{conditional}}{\sigma^2_{unconditional}}$$

In level 1, the variance amount obtained after the analysis by adding only the student gender variable to the model as a predictive variable was calculated to be 5471,61. The variance amount created for the null model which was created without addition of any independent variables to the model was determined to be 5519,19. Accordingly, the variance amount disclosed when we include the gender variable to the model will decrease nearly by 1% (5519,19-5471,61/5519,19) . It was determined that the variables like number of computers, number of tables, age, self-efficacy level, mother and father education level which were found to have a significant effect in predicting the mathematics literacy would reduce the undisclosed variance by nearly 2% (Anderson, 2012).

In the second stage of the study, we attempted to determine the effects of the school level variables on predicting the mathematics literacy. The variables included in this model in the second stage which had the school information are the budget type of the school, place of school, availability of option for a different school in the region, school type, state assistance, school's own revenues, number of boys, number of girls, number of teachers, number of mathematics teachers, number of students, number of computers, number of computers with internet access, school index, source index, independence status of the school, teacher-student ration, moral level of teachers, lack of teachers and classroom size. Table 6 includes the results on the model established with the school level variables on mathematics literacy.

Table 6. Estimation of the Fixed Effects on the Random Coefficient Model on the Second Level

Fixed Effects	**Coefficients**	**Standard Error**	***t*-ratio**	**s.d.**	***p.***
General Achievement Average, γ_{00}	410,26	66,33	6,18	146	0.000
School budget, γ_{01}	-24,77	50,31	-0,49	146	0.623
School location, γ_{02}	3,07	5,51	0,55	146	0.578
Different school option, γ_{03}	-9,76	6,35	-1,53	146	0.127
School type, γ_{04}	6,95	9,75	0,71	146	0.477
State assistance, γ_{05}	0,17	0,23	0,73	146	0.461
School revenues, γ_{06}	**0,74**	**0,29**	**2,50**	**146**	**0.013**
Number of boys, γ_{07}	0,00	0,02	0,41	146	0.680
Number of girls, γ_{08}	-0,00	0,02	-0,08	146	0.934
Number of teachers, γ_{09}	-0,58	0,34	-1,67	146	0.096
Number of maths teachers, γ_{010}	**10,32**	**2,18**	**4,72**	**146**	**0.000**
Number of students, γ_{011}	**-0,13**	**0,03**	**-3,63**	**146**	**0.000**
Number of computers, γ_{012}	0,06	1,38	0,04	146	0.964
Nr. of computers with internet, γ_{013}	-0,13	1,38	-0,09	146	0.922
School index, γ_{014}	-7,05	15,21	-0,46	146	0.644
Source index, γ_{015}	0,16	62,19	0,00	146	0.998
Independence status, γ_{016}	-6,82	10,39	-0,65	146	0.513
Teacher-student ratio, γ_{017}	**-2,15**	**0,99**	**-2,17**	**146**	**0.032**
Teacher moral level, γ_{018}	**12,94**	**5,04**	**2,56**	**146**	**0.011**
Lack of teachers, γ_{019}	1,85	5,27	0,35	146	0.725
Classroom size, γ_{020}	-0,33	2,34	-0,14	146	0.886

When we reviewed the Table 6, we determined that among the school level variables, the variables of school revenues, number of mathematics teachers, total number of students, teacher-student ratio and teacher moral had a significant effect in predicting the mathematics literacy ($p<.05$). According to the model, a one-unit increase in the moral level of teachers caused an increase of 12,94 points in mathematics literacy points, a one-unit increase in the number of maths teachers caused an increase of 10,32 points in mathematics literacy points, a one unit increase in the school revenues caused an increase of 0,74 points in mathematics literacy points. However, an one-unit increase in the teacher-student ratio caused a decrease of 2,15 in the mathematics literacy points, an one-unit increase in the number of students caused a decrease of 0,13 in the mathematics literacy points. Table 7 includes the estimation of the variance components on the Random Coefficients Model obtained for the variables predicting the school level literacy points.

Table 7. Estimation of the Variance Components on the Second Level Random Coefficient Model

Random Effects	Standard Deviation	Variance Components	s.d.	χ^2	p.
Okul Ortalaması, u_{0j}	61,09	3732,76	149	5352,79	0.000
Düzey-1 Etkisi, r_{ij}	56,09	3146,17			

When we examined the Table 7, we saw that the mathematics literacy points variance of the schools was estimated to be 3732,76 after adding the level 2 variables to the model, taking the general average in Turkey into consideration. In addition to that, it was determined the mathematics literacy points varied between 398,13 and 422,39 by a possibility of 95% when the student level variables are included to the model. According to this result, the variance amount between the mathematics literacy points is significantly reduced when the school level variables are included to the model. It was determined that the difference between mathematics literacy was reduced to nearly 54,26 % (3732,76/3732,76+3146,17) with the addition of school level variables to the model. According to this result, it can be said that there is a decrease of nearly 9% in the variance amount disclosed when then school level variables are added to the model. When we studied the Pseudo R^2 values calculated to determine the effect sizes of the school level variables that were determined to have a significant effect on the mathematics literacy, we observed that the variance amount of the teacher morale variable with the biggest effect disclosed in β_{0j} was 0,10. According to this result, nearly 10% of the mathematics literacy variance between schools was caused by the teacher morale variable, nearly 3% by the number of maths teachers, 14% by the teacher-student ratio and 5% by the difference in the student numbers.

In the third stage of the study, the model was created where the Dependent Variable was the Intersections and Slopes obtained by the inclusion to the analysis all of the variables which were determined to have a significant effect on the mathematics literacy at the student and school level. This model is called as full model in different sources and the student and school level descriptive variables are included to the analysis at the same time (Raudenbush & Byrk, 2002, p. 28). Table 8 includes the estimation values of the fixed effects of the model where the intersections and slopes are dependent variables.

Table 8. Estimation of the Fixed Effects on the Full Model

Sabit Etkiler	Katsayılar	Standart Hata	*t*-oranı	s.d.	p.
General Achievement Average, γ_{00}	416,57	6,07	68,57	164	0.000
School revenues, γ_{01}	0,57	0,21	2,62	164	0.009
Number of mathematics teachers, γ_{02}	8,24	1,70	4,84	164	0.000
Number of students, γ_{03}	-0,14	0,02	-5,05	164	0.000
Teacher-student ratio, γ_{04}	-1,91	0,66	-2,89	164	0.004
Teacher morale level, γ_{05}	12,13	4,54	2,67	164	0.008
Gender, γ_{10}	20,25	1,75	11,54	4668	0.000
Motivation, γ_{20}	1,14	0,35	3,21	4668	0.001
Self-efficacy, γ_{30}	3,60	0,24	14,80	4668	0.000
Attitude, γ_{40}	2,34	0,24	9,48	4668	0.000
Behaviour control, γ_{50}	1,65	0,37	4,40	4668	0.000
Mother education, γ_{60}	1,20	0,77	1,54	4668	0.122
Father education,γ_{70}	-4,18	0,72	-5,80	4668	0.000
Number of computers, γ_{80}	-10,80	1,92	-5,61	4668	0.000
Age, γ_{90}	5,81	2,76	2,10	4668	0.036
Tablet possession, γ_{100}	8,32	1,71	4,84	4668	0.000

When we reviewed the Table 8, we determined that the variables of mother education level (t=1,54, p>.01) and age (t=2,10, p>.01) didn't have a significant effect in predicting the mathematics literacy when all of the first level and second level variables are included to the analysis. In addition, the gender variable has the most significant effect on the mathematics literacy of the students. The gender difference between the boys and girls causes a difference of 20 points in their PISA mathematics points. In addition, a one point increase in the school level teacher morale will cause in increase of 12,13 points in the mathematics literacy points and a one point increase of 1 point in the number of mathematics teacher will cause an increase of 8,24 points in mathematics literacy. A one point increase in the student level variable of tablet possession will cause an increase of 8,32 points in the mathematics literacy and a one point increase in the self-efficacy level will cause an increase of 3,60 points. However, a one-point increase in the teacher-student ratio will cause a decrease of 1,91 point and a one-point increase in the number of students will cause a decrease of 0,14 point in mathematics literacy. At the student level, a 1 point increase in the number of computers of the students will cause a decrease of 10,80 points in mathematics literacy. Table 9 includes the estimation of the variance components on the Full Model obtained for the variables predicting the student level and school level mathematics literacy points.

Table 9. Estimation of Variance Components on the Full Model

Random Effects	Standard Deviation	Variance Components	s.d.	χ^2	*p.*
School Average, u_{0j}	59,76	3572,04	164	6301,65	0.000
Level-1 Effect, r_{ij}	52,59	2766,05			

When we studied the Table 9, we found that the variance of the mathematics literacy of schools for the full model was estimated to be 3572,76 when the general average in Turkey was taken into consideration. In addition, it was determined that the mathematics literacy points varied between 282,17 and 550,97 when the student and school level variables are included in the model by a 95% possibility. According to this result, the variance amount between the mathematics literacy points has a significant increase when the variables of both levels are included to the model. It was determined that the difference between mathematics literacy increase to 56,35% (3572,04/3572,04+2766,05) when the level 1 and level 2 variables were included in the model. According to this result, it can be said that there is a nearly 2% decrease in the disclosed variance amount when the student level variables are added to the school level variables. When we review the ranges of the mathematics literacy points, we observe that the range value increases to 75,96 when the student level variables are added to the model while the range value in the null model was 22,38. The point range for the school level variables decreases to 24,26 while the range value increases to 268,80 when all student and school level variables are added to the model. According to these values, there is a big difference between the student level points while this difference is lower at the school level.

Conclusion and Suggestions

There are various problems taking place when the analysis is done with the simple linear regression models in the data with hierarchical structure like classroom, school, region, province, state and country. Perhaps the most important one of these problems is the breach of the assumption that the observations are independent from each other (Raudenbush, 1993). Individuals that have different levels and are included in an hierarchical configuration are affected by the qualities of the groups they belong to. Individuals in a group have the tendency to be similar to each other compared to the individuals in the other groups due to the similar qualities and conditions they share (Osborne, 2002). As a result, it cannot be said that the observations from the individuals within the same group are totally independent from each other. This problem is considered through hierarchical linear models and the analyses with these models don't have the assumption related to the independence of observations (Atar, 2010).

In the event that the qualities of individuals vary from one group to another, the use of the regression analysis will cause the ignorance of the effect of the group qualities on the qualities of the individuals (Atar, 2010). Therefore, the application of the conventional multi regression models to the hierarchical data set leads to smaller calculation of the standard errors of the coefficient estimation than what it is supposed to be (Hox, 1995). The present study intended to determine whether there is student level and school level difference between the mathematics literacy performances of the students in the Turkey sample of the PISA 2012 Test. The study determined that the student level variables of gender, school type, motivation level, self-efficacy, attitude, behaviour control, causes of failure, work discipline, mother education, mother education, computer possession, age and tablet possession have a significant effect on mathematics literacy. In addition to that, the findings of the present study which revealed positive effects of the education level of parents on the mathematics achievement of the child were found to be similar with the results of the previous studies in this field (Alomar, 2006; Schmitt, Sacco, Ramey, Ramey, & Chan, 1999). On the other hand, the variables with significant effect on mathematics literacy are the level of teachers' morale, number of mathematics teachers, student-teacher ratio, school revenues and student numbers. Güvendir (2017) attempted to determine the relations between the mathematics literacy of students in PISA 2012 and the education possibilities in their homes and schools. Possession of personal computer was found to be the second variable with the highest relation. The finding of the study that the computer possession variable of students has a statistically significant effect on the mathematics literacy at schools is considered to be matching with the result reached by Güvendir (2017).

There are different studies in the literature that revealed that the sex variable affected the mathematics literacy (Ovayolu, 2010; Uysal & Yenilmez, 2011; Stacey, 2011; Özer & Özberk, 2011). The fact that the sex variable among the independent variables has a significant effect on mathematics literacy is supported by the study of Koğar (2015) which aimed to determine the variables affecting the mathematics literacy according to the PISA 2012 data, however, it varies with the finding that the social and cultural status index had no significant effect in mathematics literacy. In his study, Koğar (2015) found that the mediating variable that defined the mathematics literacy the most was the mathematics self-efficacy. The two results are considered to be supporting each other. The study by Özer and Anıl (2011) established a structural equation model and determined that the time spared for studying was the most important variable that predicted the students achievements according to the PISA 2006 data. However, the present study, which analyzed simultaneously the student levels and schools levels, found that sparing more time to mathematics including attendance to class and participation in courses had no significant effect on the mathematics literacy according to the PISA 2012 data. On the other hand, the fact that the variable of teacher-student relation has no significant effect on the mathematics literacy is similar to the findings of the study by Yurt (2014). The reason of similarity is believed to be the fact the method, strategy and techniques used by the teachers are different. İn addition to study findings variables of interest, mathematics related behaviour, teacher-student relation, attendance, participation in mathematics courses and socio-economic variables don't have a significant effect on mathematics literacy. As a result of the study, the variables that predict the mathematics literacy the best are similar to the findings of the previous studies in the literature (Aksu & Güzeller, 2016). The fact the variables of self-efficacy, interest, attitude and motivation predict the mathematics literacy the most is supported by the results of the study by Şahin and Yıldırım (2016) which examined the variables that affect the mathematical behaviours and mathematics literacy through multi grouped hybrid modelling.

Özberk, Atalay Kabasakal and Öztürk (2017) examined the factors affecting the mathematics achievement in PISA 2012 by using hierarchical linear model and found that the mathematics self-efficacy of students affected the mathematics performance significantly. The result of the study which indicated that the self-efficacy variable is one of the most important variables with respect to mathematics literacy matches with the result obtained by Özberk et al. (2017). Thien, Darmawan, and Ong (2015) examined some factors affecting the mathematics performance of the students from Malaysia and Singapore who participated in PISA 2012 through hierarchical linear model and found that the mathematics self-efficacy of both the Malaysian and Singaporean students had a significant and important effect on the mathematics performance. The result of the study which indicated that the self-efficacy variable is one of the most important variables with regards to its effect no mathematics literacy matches with the result obtained by Thien et al. (2015).

A study by Fonseca, Valente and Conboy (2011) used the hierarchical regression analysis to test the economic and educational qualities of the school at school level and the gender and socioeconomic status and affective qualities towards the science lesson at student level in the interpretation of the Science literacy of the Portuguese students in the PISA 2006 test. The fact that the variable of gender predicts the science literacy the best at the student level is similar to the findings of the present study. However, the socio-economic level has a significant effect on the science literacy of the Portuguese students while this variable has no significant effect in the Turkey sample. The hierarchical regression analysis in the study by Yılmaz and Aztekin (2012) indicated that the variable of socio-economic level has a significant effect on the mathematics literacy. This result contradicts with the findings of this study. In addition to that, the ratio of mathematics teacher and the teacher-student ratio has a significant effect, while the the lack of education material and low number of mathematics teachers have no statistical effect on the averages of the schools which is similar to the findings of our study (Yılmaz & Aztekin, 2012).

The fact that the variables of school type and attitude have a significant effect in the model in the hierarchical regression analysis conducted in the Turkey sample of the PISA 2006 test is similar to the findings of the study. However, it was determined that the variables of number of computers, number of computers with Internet access, source quality and socio-economic level index have no significant effect on the mathematics literacy while they were found to be effective in sciences literacy (Acar & Öğretmen, 2012). The reason of this difference is believed to be the fact that the science subjects are more updated and require further studies compared to mathematics. Hence, the number of computers in the school and the access to İnternet as well as the quality of the education resources of the school have no significant effect on the mathematics literacy contrary to the sciences literacy. The socio-economic level of a school is the total criteria of the social history of the students attending to that school (Milford, 2010). The increase in the socio-economic level of the school is associated with the increase in the mathematics achievements of the individuals regardless of the increases in the socio-economic levels of the individuals (Hsu, 2007; Perry & Mcconney, 2010). There are studies in the literature demonstrating high relation between the mathematics achievement and the socio-economic level of the school (Milford, 2010; Shin & Slater, 2010). However, the fact that the school level variables, except the school revenue, didn't have a significant effect in the model according to the findings of the present study contradicts with the findings of the other studies in the literature. The reason of this difference is believed to be based on the fact that the studies were conducted in two different communities and that the state supports varied in different cultures.

The fact that the variable of attitude had a significant effect on the science literacy in the study where the TIMSS Turkey data was analysed by the hierarchical regression model is similar to the results of this study (Atar, 2010). In addition, the fact that the school material has no significant effect in the model is similar to the findings of this study.

In a study where the PISA 2009, in the meaning of Albania data were tested by two-stage regression analysis, the difference between schools explains 22% of the total variance (Shera, 2014). This result is similar to the findings of the present study while the ratio of difference between schools to disclose the total variance in the PISA mathematics achievement is as high as 63%. According to this result, it can be said that the schools in Turkey have a quite heterogeneous structure with respect to the mathematics literacy. Likewise, this result is supported by the fact that the real point range of the mathematics literacy points in the Turkey sample increased from 22,38 to 287,99 after the inclusion of the school variable to the model in the second level. Another reason of obtaining this result is believed to be the fact that the group differences among individuals with respect to the qualities studied can be determine more accurately with the HLM analysis (Anderson, 2012).

The fact that the difference between the mathematics literacy of the students was found to be nearly 67% after the inclusion of the student level variables to the hierarchical regression analysis is similar to the findings of the study conducted by Lin et al. (2006). This difference is determined to be 65% in mathematics literacy, 63% in science and 60% in reading skills for the students from Taiwan. The results obtained from the study indicate that the group qualities that affect the individual qualities can be modelled more accurately and correctly with the help of hierarchical linear models (Garson, 2013).

A similar study can be conducted using data obtained from other international studies such as TIMMS and PIRLS in order to comfirm PISA data and findings in the future crosswisely.

This study represents multilevel analysis of in order to analyze the relationships between variables at the level of student, school and maths performance in the PISA 2012 Turkey sampling, and contributes Turkey to form policy based on evidence. In practical terms, findings obtained at the end of the study are considered to direct and guide forthcoming researches in the context of providing emprical evidences about how the variables in the study effect the maths performance. This study is hoped to be not only a reference of knowledge and emprical evidence but also an assistance for understanding the effects of policies on educational outcomes better.

When the properties of the questions in PISA 2012 student survey are considered, it can pla6y a role in survey forms' having a very general structure, and for this reason, it might not include the learning characteristics of students. Moreover, translation of survey questions creates a potential for losing the unity of equivalance of the question from one country to another (Ram, 2007). Student and school variables used in this study constitute only a part of variabilities in maths performance. Maths performance of students depends on different factors contributing to the big part of unexplained variance, such as teachers' teaching applications, the socio economic structure of schools and school sources (O'Dwyer, Wang, & Shields, 2015; Rumberger & Palardy, 2005; Topçu, Arıkan, & Erbilgin, 2014; Thien et al., 2015). These variables contributing to a big part of unexplained variance can be used in the studies that have the same topic.

The relationships of the variables in the context of the study with maths literacy were analyzed. In the future, researches related to structural equation modeling, which enables the analysis of relations between the same variables eachother, can be conducted. Besides, this study is limited with some variables obtained from student and school survey so a hierachical linear modelling analysis can be conducted by addressing the student and school level variables obtained from student and administrator questionnaires in the forthcoming studies (Yavuz, Dibek, & Yalçın, 2017).

Also, because our understanding about the affective chgaracteristics depending on a multicultural perspective can be improved with a deeper investigating, hypothetical explanations related to the results of the study should be analyzed with similar studies emprically and qualitatively. The studies to be conducted in accordance with this purpose will help to identify the ways of changing educational applications and systems in order to have better educational outcomes. On the other hand, it should be noted that not all of the variables related to maths performance were included in this study.

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