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Determination of the Relationship between the Students' "Mathematical Literacy" and "Home and School Educational Resources" in Program for International Student Assessment - (PISA 2012)

Uluslararası Öğrenci Değerlendirme Programında Öğrencilerin Matematik Okuryazarlıkları ile Ev ve Okul Eğitim Olanakları Arasındaki İlişkinin Belirlenmesi - (PISA-2012)

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Abstract: The purpose of the study is to examine how home (desk, private study room, a quiet place to study, computer, internet connectivity, textbook, and DVD player) and school educational resources (public or private, school location, class size, shortage of mathematics teachers, instructional materials, Internet connection, library materials, buildings and grounds, heating, cooling and lighting) are related to students' mathematical literacy in PISA 2012. The students in Turkey who attended PISA 2012 form the sample of this study. The sample of the study involves 4308 students and 157 schools. (Turkish sample of PISA 2012 consists of 4848 students from 170 schools, but in this study, missing values in 13 schools were removed from the analysis before hierarchical linear modeling was done). Hierarchical linear model (HLM) was used for data analysis. The variables at student level (Level 1) which are related to mathematical literacy are having a study desk, computer, textbook, and DVD player. According to the results when the students have a study desk, computer, textbook, and DVD player, their mathematical literacy increases. The variable at school level (Level 2), which is related to mathematical literacy is having Internet connection at school.
Keywords: Hierarchical linear model, home and school educational resources, mathematical literacy, Program for International Student Assessment-(PISA)

Öz: Bu araştırmanın amacı, Uluslarası Öğrenci Değerlendirme Programı (PISA) 2012'de öğrencilerin matematik okuryazarlıkları ile ev (çalışma masası, kendine ait oda, sessiz bir çalışma yeri, bilgisayar, internet bağlantısı, çalışma kitabı, DVD oynatıcısı) ve okul (okul türü, bölgesi, sınıf büyüklüğü, matematik öğretmeni eksikliği, öğretimsel materyaller, internet bağlantısı, kütüphane materyalleri, binalar ve alanlar, ısınma, soğutma ve aydınlatma) eğitim olanakları arasındaki ilişkiyi incelemektir. PISA 2012'ye katılmış olan Türkiye'deki 157 okuldan, 4308 15 yaş grubu öğrenciler, bu araştırmanın örneklemini oluşturmaktadır (PISA Türkiye örneklemi 170 okuldan 4848 öğrencidir; ancak HLM'ye başlamadan önce 13 okula ait kayıp veriler veri setinden çıkarılmıştır). Verilerin analizinde, veriler içe içe yapı gösterdiği için hiyeraşik lineer model kullanılmıştır. Öğrenci düzeyinde matematik okuryazarlığı ile ilişkili olan değişkenler; çalışma masası, bilgisayar, çalışma kitabı ve DVD oynatıcısıdır. Buna göre, çalışma masası, bilgisayar, çalışma kitabı ve DVD oynatıcısına sahip olan öğrencilerin matematik okuryazarlığı daha yüksektir. Okul düzeyinde matematik okuryazarlığı ile ilişkili olan değişken ise okulda internet bağlantısının olmasıdır.
Anahtar Kelimeler: Ev ve okul eğitim olanakları, hiyerarşik lineer model, matematik okuryazarlığı, Uluslararası Öğrenci Değerlendirme Programı (PISA)

Introduction

Evaluation of the overall education process contributes to recognize final behavioral outcomes and fulfillment of the initial expectations of education. Such an evaluation basically includes

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identification of the learning environments (Fisher, 2005; Walsh & Gardner, 2005), the effectiveness of the education programs (Berk, 2005; Kassebaum, 1990), and students' learning levels (Briggs, 1993). In order to determine the learning levels, students' achievement should be periodically and objectively measured and evaluated through classroom tests and large scale tests. While classroom tests are used to measure failure or success, large scale tests do not try to determine whether students will fail or pass. They rather aim to measure students' level of achievement. Moreover, they have a significant role in identifying the incompetency of students and the reasons that cause it (Chudowsky & Pellegrino, 2003). Assessment is necessary for determining to see whether curriculum has achieved its goals and to organize teaching according to students' readiness (Tekin, 2004). According to Baykul (2011), at the end of educational procedures, it is possible to face unpredicted situations, undesired outcomes, and unintended behavioral outcomes. Thus, examinations are conducted either at the end of the educational procedure or at particular points during education. These examinations are terminologically described as "assessment".

Assessing student achievement has been one of the key goals of national and international organizations for many years. Thus, national and international large scale tests are frequently used by many countries to identify students' national and international achievement ranks. The large scale tests in general include several tests that contain knowledge and skills that have been previously specified for different grades and courses. These tests are implemented on large student groups (Çakan, 2003). For instance, in Turkey, Educational Research and Development Department (EARGED), which is a branch of Republic of Turkey Ministry of Education (MEB), conducts Student Achievement Determination Exam (ÖBBS) in order to measure student achievement in primary and secondary education. Starting from 2002, ÖBBS has been conducted every three years. Fourth, fifth, sixth, seventh, and eighth grade students take it. It consists of Turkish, mathematics, science and technology, social sciences, and English language segments. The reasons for using ÖBBS to measure student achievement in these five main areas are: 1) to monitor the efficacy of compulsory schooling in Turkey, 2) to determine the factors that high quality compulsory schooling is linked to, and 3) to decide the activities that can be used to increase the productivity of compulsory schooling to the desired level (MEB, 2002; 2007a; 2009).

At international level, with the purpose of continuously determining international student achievement, Organization for Economic Co-operation and Development (OECD) and International Association for The Evaluation of Educational Achievement (IEA) have been organizing international exams such as The Progress in International Reading Literacy Study (PIRLS) which measures fourth grade students' reading skills and its improvements (MEB, 2003a; timssandpirls.bc.edu), and Trends in International Mathematics and Science Study (TIMSS) that measures students' mathematics and science achievement every four-years (MEB, 2003b; timssandpirls.bc.edu). Program for International Student Assessment-(PISA) (MEB, 2003a; 2003b; 2005; 2007b; Rutkowski, Gonzalez, Joncas & von Davier, 2010) administered by OECD, is a comprehensive and detailed international program that assesses 15 years old students' reading, mathematics, and science skills in a three-year period and collects data about student, family, and school components for explaining the differences of these skills (MEB, 2005; 2007b). This program has been collecting data about students' motivation, opinions about themselves, learning styles, school environments, and families.

These international large scale tests measure knowledge and skills that students will use in knowledge based society. These knowledge and skills are reading, mathematics, and science. Knowledge and skills in various majors are determined by using achievement tests and information about students, teachers, and schools are collected by using surveys (MEB, 2003a; 2003b; 2005; 2007b). These surveys reveal specific information about students' home resources such as having a computer, Internet connection, private study room etc. (Duncan & Brooks-Gunn, 1997; Şirin, 2005). For example, PISA categorizes resources such as having a private study desk, private room, study place, computer, Internet, textbook, and DVD player as home educational resources. İş Güzel (2006), Demir, Kılıç, and Ünal (2010), Ziya, Doğan, and

Kelecioğlu (2010), and Özer and Anıl (2011), and Özer Özkan and Acar Güvendir (2014) found that home resources are related to mathematical literacy in PISA. Similarly, Akyüz (2006) found that the students' home resources have relationships with mathematics achievement in TIMSS. As reported by Atar and Atar (2012) the availability of home resources affects students' achievement in TIMSS. According to Demir, Kılıç, and Ünal (2010), shortage or inadequacy of computers negatively affects students' mathematics achievement and a lack of qualified mathematics teacher has negative impacts on students' mathematics scores. Ziya, Doğan and Kelecioğlu (2010) stated that having a computer and using it for educational purposes affect mathematics achievement. According to Özer and Anıl (2011), having a computer and Internet connection positively influence mathematics achievement.

The specific research in other areas of education that examined home and school educational resources and their relationship with student achievement have presented that these educational resources are related to student achievement. For example, studies by Juan and Visser (2017) Nes et al. (2014), Thao (2003), and Grilli, Pennoni, Rampichini and Romeo (2016) show that students who have adequate home resources in their home environment have higher academic achievement. Studies related to home computer access found correlations between achievement and having access to computer at home (Attewell & Battle, 1999; Attewell, SuazoGarcia & Battle, 2003; Borzekowski & Robinson, 2005; Fiorini, 2010; Jackson et al., 2006; Judge, 2005). According to Roscigno and Ainsworth-Darnell (1999), Teachman (1987), and Juan and Visser (2017) there is a strong positive relationship between home resources such as computer, books and student achievement. Juan and Visser (2017) and Teachman (1987) stated that if students have access to books or reading material, this offers an advantageous atmosphere for studying and makes students better learners.

Another topic that has been addressed by large scale tests is school educational resources and their relation with student achievement. For instance, PISA focuses on school educational resources such as school location, class size, and unavailability of teachers, materials, Internet, library, building, and heat. According to PISA, these are indicators of school facilities and PISA examines the relation between students' literacy and school educational resources. Studies conducted in Turkey have shown that schools located in urban and rural areas provide different resources that influence students' academic achievement. Rural schools have many problems such as lack of financial resources, educational equipment, and physical conditions of school buildings, technological resources, and libraries, unavailability of teachers etc. Hence, these problems create a gap between the academic achievement of urban schools and rural schools (Acar Güvendir, 2014; Adaman & Keyder, 2006; Gedikoğlu, 2005; Güvendir, 2015; Özer Özkan & Acar Güvendir, 2014). Studies in other parts of the world also provide similar findings with that of Turkey. Raudenbush, Cheong and Fotiu (1996), Goddard, Sweetland and Hoy (2000), Abbott, Joireman and Stroh (2002), Lee, Zuze and Ross (2005), Berliner (2009), Fullarton, Lokan, Lamb and Ainley (2003), and Shiqi (2006) found that there is a relationship between school location and achievement. According to Berliner (2009) schools whose presence limits contain nonfunctional neighborhoods face greater challenges in nurturing student achievement than do those that draw students from wealthier neighborhoods. Using TIMSS data, Stephen (2002), Fullarton et.al. (2003) claimed that if the school is in a wealthy neighborhood, the students who study in this school are more successful in terms of mathematics than other schools located in poorer neighborhoods. Also class size of school is an important issue for students' achievement. According to Juan and Visser (2017) and Nye, Hedges and Konstantopoulos (2000), smaller class sizes are positively related to higher levels of achievement. These effects become higher as the class sizes are reduced.

In relation to the lack of school resources, Aslanoğlu (2007) found through her research on PIRLS that schools, which had libraries, were more successful than schools that did not have libraries. Using PISA data, Acar and Öğretmen (2012) found that the availability of computers and Internet access in schools have a positive relation with students' achievement. The study by Mullis, Martin, Foy, and Arora (2012) on TIMSS 2011 showed that, on average, successful schools were more likely to have more instructional materials, such as computers. In a study that examined PISA 2003 data, İş Güzel (2006) found that the ratio of the mathematics teachers and students in a school has an important relation with mathematics achievement. Similarly, Çalışkan (2008) stated that lack of teachers in a school negatively relates to students' achievement. If the school does not have adequate number of teachers, the school's success will be lower than the schools that have more teachers. These studies have focused on either home educational resources or school educational resources and their relationship with mathematics achievement. Different from these studies this research addresses both home educational resources and school educational resources concomitantly. The purpose of the study is to examine how home and school educational resources are related to students' mathematical literacy in PISA 2012. In particular, this study addresses the following research questions:

1. Do the students' mathematical literacies vary among the schools in PISA 2012?
2. What are the home educational resources that are related to students' mathematical literacy in PISA 2012?
3. What are the school educational resources that are related to students' mathematical literacy in PISA 2012?

Method

This research uses *correlational research model* in order to examine the relationship between home educational resources (desk, own room, a quiet place to study, computer, Internet connectivity, textbook, DVD player), school educational resources (public or private, school location, class size, shortage of mathematics teachers, instructional materials, Internet connection, library materials, buildings and grounds, heating, cooling and lighting) and mathematical literacy in the PISA 2012. "The correlational method is a type of nonexperimental method that describes the relationship between two measured variables (Jackson, 2015, 48)."

Sample

The universe of PISA 2012 in relation to Turkey forms approximately 1 million, 15 years-old students. The sample of the study consists of 4308 students from 157 schools in Turkey who participated in PISA 2012 (The Turkey sample of PISA 2012 includes 4848 students from 170 schools, but in this study missing values in 13 schools were removed from the analysis before HLM was done). The sample of PISA was designated according to statistical region units level 1. In order for the sample to represent the universe, particular steps that are based on stratified sampling were followed in PISA. The sample of PISA was formed by random sampling method from 15 years-old students who studied at schools which were selected by considering specific strata that reflected geographical structure of Turkey. In this study, whole statistics of the study were conducted via this sample that was weighted on home (student-level 1) and school (level 2). Weighted sampling was preferred to make appropriate estimates that are based on results of the study.

Data Collection Tools

The researcher in this study used the data that was obtained from OECD (https://www.oecd.org/pisa/pisaproducts/pisa2012database-downloadabledata.htm). PISA contains student, teacher, parents, school questionnaires and mathematics, science, and reading literacy tests. PISA acquired information about the home educational resources variables (desk, own room, a quiet place to study, computer, internet connectivity, textbook, DVD player) through the "Yes" and "No" responses that the students had given for "Which of the following are in your home?" question in the student questionnaire. The code "1" stood for "Yes" response and the code "0" represented "No" response. The researcher in the current study specified the home educational resources variables as Level 1 for the data analysis.

The students' school educational resources (class size, shortage of mathematics teachers, instructional materials, Internet connectivity, library materials, buildings and grounds, heating, cooling and lighting) were used for Level 2. The code "1" stood for "Not at all" response and the code "2" represented "Very little" response, the code "3" represented "To some extent" response, and the code "4" represented "A lot" response (the question for the variable is: "Is your school's capacity to provide instruction hindered by any of the following issues?". The code "1" represented "Public School" response and the code "2" represented "Private School" response for school type variable (the question for the variable is: "Is your school a public or a private school?"). The code "1" represented "Village" response, the code "2" represented "Small town" response, the code "3" represented "Town" response, the code "4" represented "City" response, and the code "5" represented "Large city" response for school location variable (the question for the variable is that "Which of the following definitions best describes the community in which your school is located?"). All of the explanatory variables are on ordinal scale. Also mathematical literacy test was used for determining the students' mathematical literacy scores.

Data Analysis

PISA 2012 mathematics data set is used in this study. HLM was used for determining the relationship between the students' mathematical literacy and home and school educational resources. HLM is often used in social sciences research to estimate a measurement model in which multiple measurement items are hypothesized to assess a particular latent construct. HLM is used when the data structure is hierarchical with units at Level 1 nested in clusters at Level 2, which in turn may be nested in clusters at Level 3, and so on. The important thing is that the structure of the data should be nested (Raudenbush & Bryk, 2002; Snijders & Bosker, 1999). HLM is a particiular regression model that is designed to take hierarchical structure of educational data into consideration (Raudenbush & Bryk, 2002). HLM is preferred as a modeling technique because of the nested structure of the data sets and sampling procedures used in data collection of PISA project. Educational data have a hierarchical structure, as students are nested in classrooms, classrooms are nested in schools, whereas schools are nested in cities, and cities are nested in regions etc. On the other hand, all the relations between home (student) level factors, school level factors and mathematical literacy performance could be investigated in HLM. Hierarchical linear models have been used in achieving three general research purposes: improved estimation of effects within individual units; modeling cross-level effects; and partitioning of variance and covariance components among levels.

The students' home educational resources (desk, own room, a quiet place to study, computer, internet connectivity, textbook, DVD player) presented Level 1. The students' school educational resources (public or private, school location, class size, shortage of mathematics teachers, instructional materials, Internet connection, library materials, buildings and grounds, heating, cooling and lighting) forms Level 2. The students' mathematics scores in PISA 2012 were considered as outcome variables. PISA uses attribution methodology and reports the student performance through plausible values. Plausible values are a mixture of possible proficiencies for the students that reached each score. PISA 2012 student data contains plausible values for science, mathematics, and reading. Also there are five plausible values for each of the scales. In this study, the mean of the mathematics scales (PV1MATH to PV5MATH) was used as an outcome variable.

One-way ANOVA with Random effects, Means-as-outcomes regression model, The Random Coefficient Regression Model, are used in two level HLM. As Raudenbush and Bryk, (2002, p.26) put it, "the simplest possible hierarchical linear model is equivalent to a one-way ANOVA with random effects. This model is fully unconditional i.e. no predictors are specified at either Level 1 or 2. Means-as-outcomes regression model determines whether means from each of many groups as an outcome to be predicted by group characteristics. Random-coefficients regression model is the simplest case of this type. In these models, both the Level-1 intercept and one or more Level-1 slopes vary randomly, but no attempt is made to predict this variation."

In quantitative research, it is essential that the variables under study have precise meaning so that statistical results can be related to the theoretical concerns that motivate the research. In the case of hierarchical linear models, the intercept and slopes in the level-1 model become outcome variables at level-2. It is vital that the meaning of these outcome variables be clearly understood (Raudenbush & Bryk, 2002, 31). The meaning of the intercept in the level-1 model depends on the location of the level-1 predictor variables, the Xs. Similarly, interpretations regarding the intercepts in the level-2 models depend on the location of the Wj variables. The numerical stability of estimation is not affected by the location for the Ws, but a suitable choice will ease interpretation of results (Raudenbush & Bryk, 2002, 32). In this study, two types of centering (group-mean centering and grand-mean centering) were used. Home level factors (student-level-1 variables) were centered around the group mean. On the other hand, grand mean centering was used for the school level factors (level-2 variables).

While SPSS 17.0 and Microsoft Excel 2010 were used for data organization, HLM 7.0 was used for HLM. The level of the statistics obtained from the study was considered as minimum .05 in the significance test.

Findings

Two level HLM was used to determine home and school educational resources that are related to students' mathematical literacy in PISA 2012. In HLM, one-way ANOVA with random effects model was used to examine whether mathematical literacy displays a significant difference among the 157 schools. Table 1 shows findings related to that model.

Table 1. *Final Estimation of Fixed Effects in One-Way ANOVA with Random Effects Model*

Fixed Effect	Coefficient	Standard Error	t-ratio	p-value
Intercept., γ_{00}	444.71	5.93	75.05	.00

Considering the results on Table 1, the fixed parameters are significant (χ^2=9955.22, p<.01). Mathematical literacy displays a significant difference among schools. This result means that the mean value of the mathematical literacy among the 157 schools that participated in PISA 2012 varies significantly. Thus, students at school A have different mathematics scores than students at school B.

Table 2. *Final Estimation of Variance Components in One-Way ANOVA with Random Effects Model*

Random Effect	Standart Deviation	Variance Component	χ2	p-value
Level 2	73.45	5394.49	9955.22	.00
Level 1	50.64	2564.38		

The one-way ANOVA with random effects model separates the total variance that belongs to mathematical literacy score into two components. These components are the variance among students at schools (Level-1) and the variance among schools (Level-2). These components are demonstrated as follows:

$$\sigma^2/(\sigma^2+\tau_\beta)=2564.38/(2564.38+5394.49)=0.32$$

$$\tau_{00}/(\sigma^2+\tau_{00})= 5394.49/(5394.49+2564.38)=0.68$$

According to these results, while 32% of total variance originates from the difference among students, 68% is the result of the difference among schools.

Following the model 1, the study examined the relationship between the variables in both levels. The correlation values between explanatory variables in the Level 1 are shown in Table 2.

Level 1 Model;

$$Math\ Score(Y_{ij})=\beta_{0j}+\beta_{1j}*(Desk_{ij})+\beta_{2j}*(Ownroom_{ij})+\beta_{3j}*(Study\ Place_{ij})+\beta_{4j}*(Computer_{ij})+\beta_{5j}*(Internet_{ij}) + \beta_{6j}*(Textbook_{ij}) + \beta_{7j}*(DVD_{ij})+ r_{ij}$$

Level 2 Model;

$\beta_{0j}=\gamma_{00}+\gamma_{01}$*(School Type$_j$)+$\gamma_{02}$*(Location$_j$)+ γ_{03}*(Class size$_j$)+γ_{04}*(Teacher$_j$)+ γ_{05}*(Material$_j$)+ γ_{06}*(Internet$_j$)+ γ_{07}*(Library$_j$)+ γ_{08}*(Building$_j$)+ γ_{09}*(Heat$_j$)+ u_{0j}

$\beta_{1j}=\gamma_{10}+\gamma_{11}$

$\beta_{2j}=\gamma_{20}+\gamma_{21}$

$\beta_{3j}=\gamma_{30}+\gamma_{31}$

$\beta_{4j}=\gamma_{40}+\gamma_{41}$

$\beta_{5j}=\gamma_{50}+\gamma_{51}$

$\beta_{6j}=\gamma_{60}+\gamma_{61}$

$\beta_{7j}=\gamma_{70}+\gamma_{71}$

$\beta_{8j}=\gamma_{80}+\gamma_{81}$

$\beta_{9j}=\gamma_{90}+\gamma_{91}$

Table 3. *Final Estimation of Fixed Effects in Means-as-outcomes regression model and The Random Coefficient Regression Model*

Fixed Effect	Coefficient	Standard Error	t-ratio	p-value	Reliability Estimate	Effect Size*
Intercept., γ_{00}[1]	444.68	5.93	75.05	0.00	0.99	
Desk, γ_{10}	10.93	2.77	3.95	**0.00**	0.11	0.30
Ownroom, γ_{20}	-2.89	2.14	-1.35	0.18	0.15	0.11
Study Place, γ_{30}	4.01	2.40	1.67	0.10	0.08	0.13
Computer, γ_{40}	10.58	2.77	3.82	**0.00**	0.16	0.29
Internet, γ_{50}	-2.19	2.66	-0.82	0.41	0.21	0.07
Textbookγ_{60}	5.30	2.34	2.27	**0.03**	0.11	0.18
DVDγ_{70}	3.91	1.72	2.28	**0.02**	0.03	0.18
Intercept., γ_{00}	444.72	5.71	77.82	0.00		
School Type$_j$ γ_{10}	43.99	51.76	0.85	0.40		0.07
Location γ_{20}	-1.91	5.68	-0.34	0.74		0.03
Class sizeγ_{30}	-4.03	2.58	-1.56	0.12		0.13
Teacherγ_{40}	-6.56	6.72	-0.98	0.33		0.08
Materialγ_{50}	5.38	7.58	0.71	0.48		0.06
Internetγ_{60}	-19.04	7.61	-2.50	**0.01**		0.20
Library γ_{70}	-8.77	7.60	-1.15	0.25		0.09
Building γ_{80}	-4.96	6.18	-0.80	0.42		0.07
Heatγ_{90}	0.27	7.56	0.04	0.97		0.00

*Refer to the link http://www.uccs.edu/lbecker/index.html for the calculation of effect size.

Table 4. *Final Estimation of Variance Components in Means-as-outcomes regression model and The Random Coefficient Regression Model*

Random Effects	Standart Deviation	Variance Component	$\chi 2$	p-value
Level 2, u_0	73.49	5400.68	3435.13	0.00
Study Place, u_3	8.79	77.29	136.13	0.02
Internet, u_5	15.90	252.92	145.89	0.01
Level 1, r	49.08	2409.26		
Level 2	70.77	5008.70	8633.88	0.00
Level 1	50.64	2564.44		

The results on Table 3 and Table 4 show that the variables at the student level that are positively related to mathematical literacy are having a private study desk, computer, textbook, and DVD player. Thus, students who have a private study desk, computer, textbook, and DVD player have higher mathematics scores than the students who lack these resources.

According to the study results, having a private room, a quiet place to study and Internet connection at home are not significantly related to students' mathematical literacy. The variable that has the highest relationship with mathematical literacy is having a private study desk at home. This variable is followed by having computer, textbook, and DVD player at home. Moreover, 6% of the student literacy variance within the school can be described by the variables examined in the model (See Acar, 2013 page 62 for the calculation procedure).

At the school level, the variable that is related to students' mathematical literacy is having Internet connection at school. Thus, the schools which have Internet connection have lower mathematics scores than the schools which do not have Internet connection. Additionally, 7% of the school mean variance can be described by the school level variables (See Acar, 2013 page 62 for the calculation procedure).

When the effect size of the variables are examined, the variable that has the highest relationship with mathematical literacy is having a study desk (effect size=.30), followed by having a computer (effect size=.29), having school Internet connection (effect size=.20), having textbooks (effect size=.18), DVD player (effect size=.18), a quiet place to study (effect size=.13), class size (effect size=.13), own room (effect size=.11), shortage of library materials (effect size=.09), mathematics teacher (effect size=.08), building and grounds (effect size=.07), having Internet connection (effect size=.07), school type (effect size=.07), shortage of instructional material (effect size=.06), school location (effect size=.03), shortage of heating, cooling and lighting (effect size=.00).

Discussion and Conclusion

In this research, the purpose was to examine how home and school educational resources are related to students' mathematical literacy in PISA 2012. Also the study addressed the following research questions which were "Do the students' mathematical literacy vary among the school in PISA 2012?", "What are the home educational resources that are related to students' mathematical literacy in PISA 2012?", and "What are the school educational resources that are related to students' mathematical literacy in PISA 2012?"

A large part of the total variability stems from the difference among the schools. The variables at the student level (Level 1) which are related to mathematical literacy are having a study desk, computer, textbook, and DVD player.

Having an own study desk at home has the highest relationship with mathematical literacy in this study. Similarly, Yang (2003) and Lynn and Mikk (2007) found that students' home possessions are related to mathematics achievement in TIMSS. According to their studies, there is a positive and high correlation between a study desk and mathematics achievement. If the students have a study desk in the home environment, their mathematics scores in TIMSS are higher than the other students who do not have a study desk at home. Ramírez (2006) also stated that if Chilean students had the same socio-economic level as students in Miami which included a study desk, they would attain similar mathematics performance. On the contrary, Ismail and Awang (2008) found that there is a low relationship between mathematics achievement and having a study desk in the home environment. As a result, mathematics score of the students who have a study desk and mathematics score of the students who do not have a study desk are not very different. In their study, while the least difference was found between those with and without study desks, the largest difference was observed between students with and without computers.

In this study, having a computer at home is another factor that is positively related to mathematical literacy. Supporting this finding, studies of home computer access have exposed similar correlations between academic achievement and having a computer at home (Attewell & Battle, 1999; Attewell, Suazo Garcia, & Battle 2003; Borzekowski & Robinson, 2005; Fiorini, 2010; Fuchs & Woessman, 2004; Güvendir, 2015; Ismail & Awang, 2008; Jackson et al., 2006; Judge, 2005; Lynn & Mikk, 2007). According to Güvendir (2015), if a student has a computer in the home environment, his/her achievement is higher than other students who do not have a computer in their home.

DVD player which is one of the technological home educational resources is also related to mathematical literacy in this study. Similarly, according to Özer Özkan and Acar Güvendir (2014) home resources such as computer and DVD player have positive relationship with mathematics achievement and literacy in ÖBBS and PISA data. “Therefore, it is necessary to develop strategies for students to effectively use computers and advanced communication technologies that can help them to improve their academic performance” (Lee et al., 2009, 226). On the contrary, Dudaite (2013) found that material wealth such as DVD player at home has a negative effect on students’ mathematics achievement.

Although having a computer and DVD player are crucial for mathematical literacy, the other technological home educational resources such as having Internet connection at home was found to have no relationship with mathematical literacy. Similarly, Jackson et al. (2006) found that Internet use had no effect on mathematics achievement. On the other hand, Toriskie (1999) claimed that Internet use had significant effect on the achievement of Hispanic children. The literature that is related to the relationship between Internet connection and student achievement provides contradicting results. For instance, Schmidt and Vanderwater (2008) noted that technological resources are crucial on student achievement. If the students use technological resources positively and for their educational goals, positive results can be estimated.

Having mathematics textbooks which is one of the student variables is related to mathematical literacy in this study. The students, who have mathematics textbooks, have higher mathematical literacy scores than the students who do not have mathematics textbooks. Similarly, many researchers stress that adequacy of mathematics textbooks are important factors in promoting student learning (Garner, 1992; Grouws & Cebulla, 2000; Jamison, Searle, Galda & Heyneman, 1981; Robitalle & Travers, 1992; Schmidt, McKnight & Raizen, 1997; Schmidt et al., 2001). Jamison, et al. (1981) found that the textbook had significant positive effects on achievement through their experimental research. The availability of textbooks increased student mathematics scores and reduced the achievement gap between urban and rural students. Research has documented a strong effect of textbooks on the mathematics content that is taught and learned (Porter, 1989; Robitalle & Travers, 1992; Schmidt, McKnight & Raizen, 1997; Schmidt et al., 2001). Garner (1992) noted, “Textbooks serve as critical vehicles for knowledge acquisition in school” (p. 53). However, the direct effect of textbooks on student achievement is difficult to establish. Undoubtedly, other variables, including quality of teaching, contributes to mathematics learning (Reys, Reys, Lapan, Holliday & Wasman, 2003), but textbooks are also related to student opportunity to learning, so textbooks help student learning (Grouws & Cebulla, 2000).

Study room, computer, textbooks, and DVD player demonstrate socio economic status (Duncan & Brooks-Gunn, 1997; Şirin, 2005). Thus, having these resources is crucial for mathematics achievement. In general, İş Güzel (2014), Demir, Kılıç and Ünal (2010), and Ziya, Doğan and Kelecioğlu (2010) stated that home resources are positively related to mathematics literacy. Also Mullis, Martin, Foy and Arora (2012) claimed that home resources have high relationship with mathematics achievement on TIMSS. Having these facilities are not easy for families with lower incomes. Policy makers should especially focus on schools in neighborhoods that include lower class families and provide facilities to them. Facilities in schools are important for the students’ achievement as they spend a considerable time at school during a day.

The variable at school level (Level 2), which is related to mathematical literacy is having Internet connection in the school. If the schools provide Internet access, mathematical literacy scores of the students, who study at these schools, are lower than the students who study at the schools which do not provide Internet connection. Fuchs and Woessmann (2004) claimed that there is a conditional relationship between student’ mathematics achievement and Internet use at school. Thus, students who never use the Internet connection at school show lower performance than students who sometimes use computers or the Internet connection at school. On the contrary, Atar and Atar (2012) and Acar and Öğretmen (2012) found that students who study at the schools that have computers with Internet access have higher science performance than the students who study at schools that do not provide this service. Further research is necessary to examine these contradicting findings on the relationship between student achievement and having access to Internet at schools.

Class size, shortage of library materials, mathematics teacher, building and grounds, school type, shortage of instructional material, school location, and shortage of heating, cooling, and lighting are not related to mathematic literacy. Whereas, Lay and Chandrasegaran (2016) claimed that school resources shortage such as low number of teachers, instructional materials, heating/cooling/lighting systems, school buildings and grounds, is positively and significantly associated with students' science achievement in Malaysia based on TIMSS data. Also, science achievement changes among students attending the three types of schools were somewhat more marked, with average science achievement highest in the big city schools followed by schools in medium sized cities, and schools in rural areas or small towns. In addition, in some countries, teacher shortages may exist partly as a result of poor working conditions. For instance, Johnson (2006) emphasized that teachers who give up the profession after a few years are more likely to leave because of poor working conditions than because of low payment. Therefore, this situation affects students' achievement. However, a study of relation between class size and achievement found that class size has almost no relationship with achievement (Hattie, 2009), while Juan and Visser (2017) and Nye, Hedges, and Konstantopoulos (2000) claimed that schools that have smaller class sizes, have higher levels of achievement. According to Hanushek and Woessmann (2017), class size is a related variable only in surroundings with low teacher quality.

The overall examination of the study findings shows that access to educational resources both at home and school is related to a student's mathematics achievement. Hence, teachers, school administrators, and educational policy makers should identify students who do not have immediate access to these resources and come up with applications that eliminate these limitations. In this sense, the gap among students' achievement might be decreased and the educational equality might be increased. The limitation of the study is the limited number of dichotomous variables. Thus, the student literacy variance within the school that is described by the level 1 variables and the school mean variance that is described by the level 2 variables are small.

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Uzun Öz

Giriş

Büyük ölçekli sınavlar öğrencilerin başarı durumlarını belirleyerek, başarı durumuyla ilişkili olan değişkenleri de ortaya koyan uluslararası veya ulusal ölçekte yürütülen geniş çaplı çalışmalardır. Büyük ölçekli sınavlardan Uluslarası Öğrenci Değerlendirme Programı- Program for International Student Assessment (PISA), İktisadi İşbirliği ve Gelişme Teşkilatı- Organization for Economic Co-operation and Development (OECD) tarafından yürütülen 15 yaş grubu öğrencilerin okuma, matematik ve fen okuryazarlıklarını üçer yıllık periyotlarla ölçen uluslararası, kapsamlı bir programdır. Bu sayede ülkeler, öğrenci başarılarının yerini uluslararası ölçekte görerek, diğer ülkelerle karşılaştırmalar yapabilmektedirler. Program her uygulamada, okuma, matematik ve fen okuryazarlıklarından birine ağırlık vermektedir. 2012'de ağırlık verilen alan matematik olup, öğrencilerin ev eğitim olanakları, aile durumları (sosyoekonomik düzey, eğitim durumu) öğretmen özellikleri ve okulları ile ilgili bilgiler de elde edilmektedir. Öğrencilerin PISA matematik okuryazarlık durumu elde edilen bu değişkenlerle ilişkili olabilir. Buradan hareketle bu çalışmada PISA 2012 Türkiye örneklemi üzerinden öğrencilerin matematik okuryazarlığı ile ilişkili olan ev ve okul eğitim olanaklarının neler olduğunun belirlenmesi amaçlanmıştır. Böylelikle öğrencinin ev ve okul eğitim olanaklarından hangilerinin matematik okuryazarlığı ile ilişkili olduğu belirlenerek hangi değişkenler üzerinde önemle durulması gerektiği ortaya konmuştur.

Yöntem

Bu araştırmada PISA 2012'de öğrencilerin matematik okuryazarlıkları ile ilişkili olan ev (çalışma masası, kendine ait oda, sessiz çalışma yeri, bilgisayar, internet, çalışma kitabı, DVD oynatıcı) ve okul (okul türü, bölgesi, sınıf büyüklüğü, matematik öğretmeni eksikliği, öğretimsel materyaller, internet bağlantısı, kütüphane materyalleri, binalar ve alanlar, ısınma, soğutma ve aydınlatma) eğitim olanakları belirlendiği için çalışma, ilişkisel araştırma modelindedir. Araştırmanın örneklemini PISA 2012'ye Türkiye'den katılmış olan 4308 15 yaş grubu öğrenci ve 157 okul oluşturmaktadır. Birinci düzey için öğrenci verileri, ikinci düzey için ise okul verileri kullanılmıştır. Araştırmanın verileri, OECD (https://www.oecd.org/pisa/) internet sayfasından elde edilmiştir. PISA'da yer alan ev (çalışma masası, kendine ait oda, sessiz bir çalışma yeri, bilgisayar, internet bağlantısı, çalışma kitabı, DVD oynatıcı) değişkenlerine "Evet" ve "Hayır" şeklinde cevap verilmiştir ve buna göre "Evet" için "1" "Hayır" için "0" kodlaması yapılmıştır. Okul değişkenlerinden, sınıf büyüklüğü, matematik öğretmeni eksikliği, öğretimsel materyaller, internet bağlantısı, kütüphane materyalleri, binalar ve alanlar, ısınma, soğutma ve aydınlatma değişkenlerine "Hiç", "Çok az", "Bir dereceye kadar" ve "Çok" şeklinde cevaplar verilmiştir. Buna göre "Hiç" için "1", "Çok az" için "2", "Bir dereceye kadar" için "3" ve "Çok" için "4" kodlaması yapılmıştır. Okul türü, "Özel" ve "Devlet" okulu şeklinde cevaplanmıştır. Buna göre "Devlet okulu" için "1", "Özel okul" için "2" kodlaması yapılmıştır. Okulun bulunduğu bölge değişkeni "Köy", "Kasaba", "İlçe", "İl" ve "Büyük şehir" şeklinde tanımlanmış ve "Köy" için "1", "Kasaba" için "2", "İlçe" için "3", "İl" için "4" ve "Büyükşehir" için "5" kodlaması yapılmıştır.

Hiyerarşik lineer modelleme, PISA 2012'de öğrencilerin matematik okulyazarlığı ile ilişkili olan ev ve okul eğitim olanaklarının belirlenmesi için kullanılmıştır. Çalışmada kullanılan veri, ev ve okul olmak üzere iki düzeyli olduğu için hiyerarşik bir yapı göstermektedir. Hiyerarşik yapılı verilerin analizinde herbir düzey birbirinden ayrı düşünülemeyeceği için çok düzeyli analizlerin kullanılması uygun olacaktır. Bu yüzden bu çalışmadaki veriler hiyerarşik bir yapıya sahip olduğu için çok düzeyli modellerden hiyerarşik lineer model kullanılmıştır. Matematik okuryazarlığı çıktı değişkenini, öğrenci düzeyindeki ev eğitim olanakları birinci düzey açıklayıcı değişkenleri, okul düzeyindeki okul eğitim olanakları da ikinci düzey açıklayıcı değişkenleri temsil etmektedir. Hiyerarşik lineer modelde tesadüfi katsayılı tek yönlü ANOVA modeli, ortalamaların çıktı olduğu regresyon modeli, tesadüfi katsayılı regresyon modeli kullanılmıştır.

Veri analiz edilmeden önce verileri düzenlemek için SPSS 17.0 ve Microsoft Excel 2010, hiyerarşik lineer model için HLM 7.0 kullanılmıştır. Manidarlık testi için .05 düzeyi esas alınmıştır.

Bulgular

Araştırma bulgularına göre, sabit parametreler manidar bulunmuştur. Matematik okuryazarlığı okullar arasında manidar bir farklılık göstermektedir. Buna göre A okulundaki öğrencilerin matematik okuryazarlık puanları B okulundaki öğrencilerden farklıdır. Tesadüfi etkili tek yönlü ANOVA modeli sonuçlarına göre, toplam varyansın %32'si öğrenciler arasındaki farklılıktan, %68 ise okullar arasındaki farklılıktan kaynaklanmaktadır.

Tesadüfi etkili regresyon modeline göre birinci düzeyde öğrencilerin matematik okuryazarlığı ile ilişkili olan değişkenler ise çalışma masası, çalışma kitabı, bilgisayar ve DVD oynatıcı değişkenleridir. Buna göre evinde çalışma masası, çalışma kitabı, bilgisayarı ve DVD oynatıcısı olan öğrencilerin matematik okuryazarlık puanı evinde bu olanaklara sahip olmayan öğrencilere göre daha yüksektir.

Ortalamaların çıktı olduğu regresyon modeline göre ikinci düzeyde matematik okuryazarlığı ile ilişkili olan değişken okulun internet bağlantısına sahip olmasıdır. Buna göre internet bağlantısı olan okullardaki öğrencilerin matematik okuryazarlığı internet bağlantısı olmayan okullarda öğrenim gören öğrencilerden daha düşüktür.

Matematik okuyazarlığı ile en yüksek ilişkiye sahip değişken çalışma masası değişkeni iken bunu bilgisayar, okulun internet bağlantısına sahip olması, çalışma kitabı, DVD oynatıcı, sessiz bir çalışma yeri, sınıf büyüklüğü, kendine ait odanın olması, kütüphane materyallerinin eksikliği, matematik öğretmeni eksikliği, bina ve alanlar, evde internet bağlantısının olması, okul türü, öğretim materyallerinin eksikliği, okulun bulunduğu yerleşim yeri, ısınma, soğutma ve aydınlatma eksikliği değişkenleri izlemektedir.

Sonuç

Bu çalışmada öğrencinin sahip olduğu çalışma masası değişkeninin matematik okuryazarlığı ile ilişkisi en yüksektir. Buna karşın okuldaki ısınma, soğutma ve aydınlatma eksikliği değişkeninin matematik okuryazarlığı ile ilişkisi en düşüktür.

Öğrencilerin ev ve okul eğitim olanakları sahip oldukları çevredeki fiziksel fırsatlarla doğrudan ilişkilidir. Bu yüzden eğitimde fırsat eşitliğinin sağlanması adına eğitim politikaları özellikle bu kaynaklara sahip olmayan öğrenciler üzerine odaklanmalı ve onların eğitimsel kaynaklara ulaşımlarını sağlamaya yönelik çalışmaları içermelidir. Böylelikle öğrenci başarıları arasındaki fark azaltılabilir ve eğitimdeki fırsat eşitliği artırılabilir.