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Investigating the Factors Affecting Turkish Students' PISA 2012 Mathematics Achievement Using Hierarchical Linear Modeling*

PISA 2012 Matematik Başarısını Etkileyen Faktörlerin Hiyerarşik Lineer Model Kullanılarak İncelenmesi

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ABSTRACT: When Turkey's mathematical literacy performance in PISA 2003 and 2012 is examined, it is seen that it has an increase of approximately 25 points between the two assessments. Despite this increase, the fact that the mathematics performance is below the OECD average leads to the need to determine what factors affect the mathematics performance of Turkish students. This study is aimed to investigate the factors affecting mathematics performance of Turkish students at school and school level. Initially Turkish sample consisted a total of 4848 students from 170 schools. As a result of examining the assumptions of the two-level hierarchical linear model; the data of 4236 students from 128 schools were included in the analysis. The results indicate that 64 % of the variability in mathematics achievement was found between schools. Variables associated with attitudes towards mathematics have significant effects on mathematics achievement. Mathematics self-efficacy has the most significant impacts on mathematics achievement after controlling remaining variables. For the school-level variables, proportion of mathematics teachers was found to be a strong predictor of a school's average mathematics achievement. However, it's been found that student-teacher ratio was the only negative predictor of mathematics achievement at school-level. School-level variables explained 44.1% of the variance in the between school difference in mean mathematics achievement.
Keywords: PISA 2012, mathematics achievement, hierarchical linear modeling

ÖZ: Türkiye'nin PISA 2003 ve 2012 uygulamalarındaki matematik okuryazarlığı performansı incelendiğinde; iki uygulama arasında yaklaşık 25 puanlık bir artışa sahip olduğu görülmektedir. Bu artışa rağmen matematik performansının OECD ortalamasının altında yer alması, Türk öğrencilerinin matematik performansını etkileyen faktörlerin neler olduğunun belirlenmesi ihtiyacını doğurmaktadır. Bu çalışmada da; Türk öğrencilerin matematik performansını etkileyen öğrenci ve okul düzeyindeki faktörlerin incelenmesi amaçlanmıştır. PISA 2012 Türkiye örneklemini 170 okuldan 4848 öğrenci oluşturmuştur. İki düzeyli hiyerarşik lineer modelin varsayımların incelenmesi sonucunda; çalışmaya 128 okuldan 4236 öğrencinin verileri analize dâhil edilmiştir. Çalışmanın sonuçlarına göre; matematik başarısındaki değişiminin %64'ü okullar arasındaki farklılıklardan oluşmaktadır. Matematiğe yönelik tutumlar ile ilişkili olan değişkenlerin matematik başarısı üzerine önemli etkileri olduğu bulunmuştur. Analizde ele alınan değişkenler kontrol edildikten sonra, matematik öz yeterliliğinin matematik başarısı üzerinde en çok etkiye sahip olan değişken olmuştur. Okul düzeyinde değişkenlere bakıldığında; matematik öğretmenlerinin oranın, bir okula ait ortalama matematik başarısının güçlü bir yordayıcısı olduğu görülmektedir. Öğrenci-öğretmen oranı ise okul düzeyindeki matematik başarısının tek negatif yordayıcısı olmuştur. Okul düzeyi değişkenleri, ortalama matematik başarısındaki okullar arasındaki farklılığın %44,1'ini açıklamıştır.
Anahtar sözcükler: PISA 2012, matematik başarısı, hiyerarşik lineer model

1. INTRODUCTION

1.1. PISA Background

The Programme for International Student Assessment (PISA) is the most representative research within international comparison research which seeks to measure the academic

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performance of 15-year-old students in mathematics, reading and science (OECD, 2004). There are 65 countries and regions participating in PISA 2012. PISA was first performed in 2000 and then repeated every three years regularly. PISA allows national policy makers to define, monitor, and measure the end-goals of their education systems and student performance over time and to compare them with those of other countries.

Turkey first joined PISA in 2003. Results from that assessment showed that, with mean mathematics performance at around 423 points and more than half of the students performing below baseline Level 2, Turkey's 15-year-olds were performing far below the OECD average. In 2006, where scientific literacy was the major domain of assessment, the picture was similar.

As shown in Figure 1, Turkey improved its mathematics performance by more than 25 points between 2003 and 2012. Turkey outperformed even in mathematics and other domains compared to other OECD countries, including Greece, Spain and Italy. As a low performing country, the factor associated with the mathematics achievement of Turkish students would have important implications for mathematics education. Current study aims to examine various factors at student and school levels using hierarchical linear modeling (HLM) in order to monitor mathematics performances of Turkish students in PISA 2012.

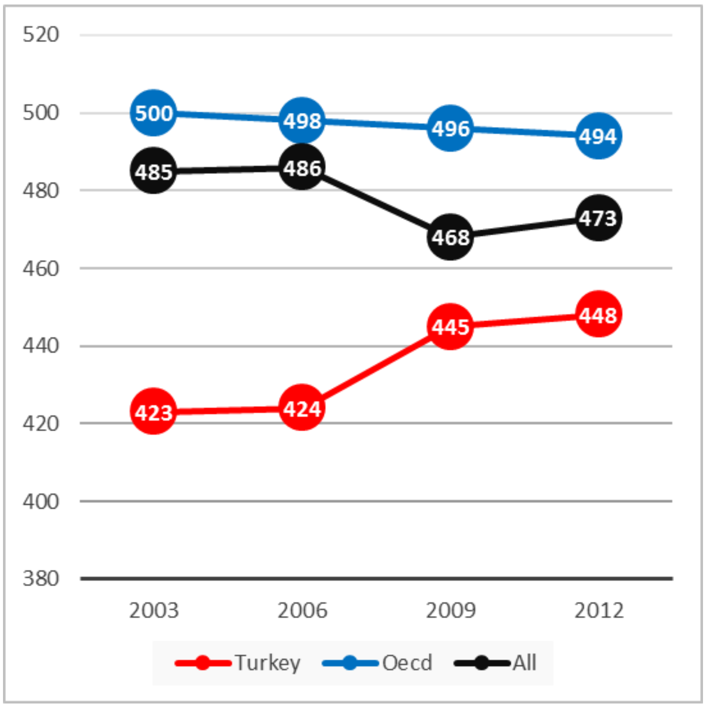

Figure 1. Turkey's Mathematics Literacy Performance by Year

1.2. Mathematics Literacy

The main purpose of PISA mathematic literacy is to discover whether students have been well prepared mathematically for future challenges in life and work (Stacey and Turner, 2015). It has been expected from students to analyze, reason and connect ideas, formulate solve and interpret mathematical problems in a variety of situation (Thomson at al., 2013). PISA defines mathematical literacy as:

> *"...an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical*

concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens. (OECD, 2013b, p.25)"

In this conception, mathematical literacy is expressed through not only using concepts of mathematics but also making judgements and understanding the effectiveness of mathematics in other domains.

1.3. Factors Affecting Mathematics Performance

Mean mathematic performance scores are generally known as the main referenced variable when determining students' mathematic performance in PISA. However, there are multiple factors that might influence students' mathematics performance. PISA uses questionnaires for both students and schools to measure various variables.

PISA 2012 had put a great emphasis on the assessment of content variables toward mathematics. Only a few studies have been done on mathematics performance of Turkish students with student and school level factors. There are many constructed indices which are helpful to discover precise performance of PISA scores.

The index of openness to problem solving (OPENPS) was constructed using student responses over handling a lot of information, understanding things quickly; seeking explanations for things, linking facts together easily and solving complex problems (OECD, 2013a). This definition basically related to students who are willing to engage with complex problems and ready to solve expected or unexpected situations. Students who are more open to problem solving generally perform at higher levels in mathematics (OECD, 2016).

The indexes related to mathematics attitudes mainly focus on the effects of constructs on mathematics achievement. Self-efficacy and self-concepts are two constructs measuring how students perceive their abilities in mathematics learning in PISA 2012. The mathematics self-concept was constructed using student responses to question over being good at mathematics, getting good grades in mathematics, learning mathematics quickly, understanding the most difficult works and so on (OECD, 2013a). A common finding across numerous studies has been that mathematical self-concept and mathematics achievement are positively related (Wang, 2007; Radišic, Videnovic and Baucal, 2015). The index of mathematics self-efficacy was constructed using student responses over the extent whether they are feeling confident about using mathematical equations and are aware of mathematics which might help to get a job and improve their career. Considerable evidence from previous research suggests that, mathematics achievement gaps diminish with the increase in mathematics self-efficacy (Kitsantas, Cheema and Ware, 2011; Liang, 2010).

The socio-economic status (SES) of Turkish students has created segregation among other OECD countries (Aydın, Sarıer and Uysal, 2012). A study by the Ministry of National Education (MEB, 2010) about the PISA studies showed that the differences between the schools and the school types are evident, and the effect of socioeconomic condition on the schools are clear.

1.4. PISA Mathematics Performance of Turkish Students

Different studies have been attempted to explore what contributes to Turkey's performance in PISA mathematics. İş Güzel and Berberoğlu (2010) studied the effects of numerous variables on students' mathematics literacy performance in PISA 2003 using structural equation modeling analysis. They found that the greatest relationship was found between self-efficacy in mathematics and mathematical literacy. Other significant relationships with Mathematical Literacy were found with the latent variables Interest in and Enjoyment of Mathematics, Anxiety in Mathematics, and Disciplinary Climate for Mathematics Lessons. Güzeller and Akın (2011) studied the relationship between the amount of time spent on homework in all subjects, the time spent on mathematics homework, confidence in doing mathematics homework and the mathematics achievement variables in PISA 2003 using multiple regression analysis. They found positive relationships between mathematics achievement and confidence in doing mathematics homework. Özer and Anıl (2011) studied factors effecting students' science and mathematics achievement in PISA 2006 using structural equating modeling analysis. They found positive relationships between mathematics achievement and confidence in doing mathematics homework. Researchers found that learning time has a positive effect on both science and mathematics literacy.

Usta (2014) studied the effects of student and school level associated with mathematical literacy performance of Finn and Turkish students attending PISA 2003 and 2012 through HLM. The researcher found that size of the place in which the school is located, pre-school education, mothers occupation, socio-cultural index and domestic educational resources were meaningful variables for Turkey. Koğar (2015) studied direct and indirect factors effecting PISA 2012 mathematical literacy performance through mediation model. The researcher found that gender, economic, social and cultural status index and time allocated for learning mathematics have a significant influence on mathematical literacy. The researcher also found that the mediation variable that explains mathematical literacy at the highest level is self-efficacy. Özbay (2015) investigated the differences mathematics, reading and science literacy performance in PISA 2012 with respect to school types and different geographical regions using MANOVA. Findings of the study demonstrated that Turkish students' performance in mathematics, reading and science differed significantly across the geographical regions and school types. Uysal (2015) studied the effect of variables determining mathematics interest, mathematics self-concept, mathematics anxiety, teacher-student relation, classroom management and sense of belonging on the Mathematics achievement of Turkish students in PISA 2012 by using structural equating modeling analysis. The researcher found that mathematics interest and mathematics self-concept had positive effect on mathematics achievement. Contrary, mathematics anxiety had negative and medium effect on mathematics achievement. Moreover, no evidence had been found on mathematics achievement among the effects of teacher-student relation, classroom management, and sense of belonging variables.

However, there are too many limitations in these studies. Mostly, the researchers include in their models a limited number of variables that they are interested in, but neglect some other variables that may be important predictors of mathematics achievement. This situation limits the interpretations of the factors affecting Turkish students' performance. Moreover, in PISA 2012 studies rotated design of the student questionnaire and missing data problem were not mentioned properly. One of the main reasons why PISA 2012 uses a rotated design or content questionnaires (CQ), was to extend the content coverage of the student questionnaire. And this rotation presents massive missing data problems.

Based on the literature review, the purpose of study is to examine various factors at student and school levels using hierarchical linear modeling (HLM) in order to monitor mathematics performances of Turkish students in PISA 2012. The factors include not only those that have been found significantly associated with performance in previous studies, such as mathematics self-efficacy and mathematics self-concept, but also some neglected but potentially important student and school factors, such as mathematics anxiety, familiarity with mathematical concepts, Home educational resources, information and communication technology (ICT) familiarity and various school educational resources. This study will explore the following questions:

1. According to the PISA 2012 results, how much do Turkish schools vary in their mathematics achievement? Does the mathematics achievement of students vary by school?
2. Which student factors have an effect on the difference of student mathematics achievement?
3. Which school characteristics have an effect on the student mathematics achievement?

Understanding variables that predict how student and school level factors affect mathematic achievement is important. Traditional regression analysis cannot be used because at a specific point, students are nested within schools. The data required for these analyses consist of both achievement and measures of students (level 1) and measures of school traits for each school (level 2) attended by the students. Thus the observations among students are not independent. Hierarchical linear modeling (HLM) consider the variance among students in the same school.

2. METHOD

2.1. Sample

The study data was obtained from the PISA 2012 Turkish data set. A two-stage stratified sampling design was used for the PISA assessment. The first-stage sampling units consisted of individual schools having 15-year-old students. Schools were sampled among PISA-eligible schools with probabilities that were proportional to a measure of size. In the second-stage sampling unit students were sampled within schools. Once schools were selected to be in the sample, a complete list of each sampled school's 15-year-old students was prepared (OECD, 2014). Prior to sampling, schools were stratified in the sampling frame by using region, programme type, school type, gender, urbanicity and funding. The stratified sampling method ensures the appropriate proportion of each type of school in the sample. Initially Turkish sample consisted a total of 4,848 students from 170 schools. The sample consisted almost equal proportion of boys (51,11%) and girls (48,89%). Due to minimum group member assumption, 42 schools were excluded from original sample. The final sampling in this study includes 4236 students from 128 schools.

2.2. Variables

The outcome variable of this study is mathematics performance which is reported as five plausible variables calculated for each student in the sample by using one-parameter (Rasch) model for dichotomous items (OECD, 2014). Each plausible value uses a posterior distribution estimating the possible scores. Five plausible variables (PV1MATH – PV5MATH) of scores were selected rather than one to facilitate unbiased estimation. The final reliability of PISA mathematics domain is 0.912 (OECD, 2014).

2.2.1. Student Level Variables

Based on the potential factor affecting mathematics achievement six of attitudes towards mathematics variables were included in this study: mathematics anxiety (ANXMAT, five items with Cronbach alpha=0.82), attributions to failure in mathematics (FAILMAT, six items with Cronbach alpha=0.66), mathematics self-efficacy (MATHEFF, eight items with Cronbach alpha=0.82), mathematics intentions (MATINTFC, five items with Cronbach alpha=0.77), mathematics self-concept (SCMAT, five items with Cronbach alpha=0.85) and subjective norms in mathematics (SUBNORM, six items with Cronbach alpha=0.71).

Another perspective to predict mathematics achievement is to look for potential contents which might have an influence on mathematics achievement. ICT familiarity, opportunity to learn concept, problem solving, economic, social and cultural status. For ICT familiarity perspective ICT entertainment use (ENTUSE, ten items with Cronbach alpha=0.90), attitudes towards computers: limitations of the computer as a tool for school learning (ICTATTNEG, three items with Cronbach alpha=0.77) and ICT resources (ICTRES) were included to validate mathematics achievement. For PISA opportunity to learn concept perspective home educational resources (HEDRES, seven items with Cronbach alpha=0.66), teacher behavior: student orientation (TCHBEHSO, four items with Cronbach alpha=0.75), experience with pure mathematics tasks at school (EXPUREM, three items with Cronbach alpha=0.92), familiarity with mathematical concept (FAMCON and its adjusted index FAMCONC, thirteen items with Cronbach alpha=0.87) were included to validate mathematics achievement. One of the last two variables is commonly used variable is the index of economic, social and cultural status (ESCS) which reflect a composite measure of parental occupation, parental education and wealth. Last variable is a new scaled index namely openness to problem solving (OPENPS, five items with Cronbach alpha=0.78) which was developed in recognition of the increasing importance of problems solving in the cognitive part of the assessment (OECD, 2014).

2.2.2. School Level Variables

School-level variables used in this study are mathematics extracurricular activities at school (MACTIV), proportion of mathematics teachers (PROPMATH), quality of school educational resources (SCMATEDU, six items with Cronbach alpha=0.83), student-teacher ratio (STRATIO) and student-related factors affecting school climate (STUDCLIM, eight items with Cronbach alpha=0.87). MACTIV is an index of mathematics extracurricular activities which asks for additional mathematics lessons, mathematic club activities and competitions. PROPMATH was computed by dividing the number of mathematics teachers by the total number of teachers. STRATIO was obtained by dividing the number of enrolled students by the total number of teachers. STUDCLIM reflects student related aspects of school climate. SCMATEDU was computed on the basis of six items measuring the school principals' perceptions of potential factors hindering instruction at school (OECD, 2014).

2.3. Handling Missing Data

In the PISA 2012 student questionnaire, the rotation of context questionnaires (CQ) were implemented for the first time. While ST01-ST28 items were in all rotated forms, ST29-ST104 items were alternately used in student questionnaire forms (OECD, 2014). As with the rotation of the cognitive assessments in the PISA 2012 survey, the rotation of the context questionnaires presents a massive missing data problem. Adams, Leitz, & Berezner (2013) have argued that rotation of the CQ is not detrimental to plausible value estimation of latent proficiency based on the full conditioning and population model approach. Kaplan and Su (2016) made a contribution to missing data problem in the PISA 2012 when they presented findings on the consequences of matrix sampling of context questionnaires for the generation of plausible values in PISA.

According to the findings of the research, Kaplan and Su (2016) examined several different PISA 2012 forms of missing data imputation within the chained equations framework by comparing predictive mean matching, Bayesian linear regression, and proportional odds logistic regression. They found that predictive mean matching accurately reproduced the marginal distributions of the missing context questionnaire data due to matrix sampling. In this research single and five imputation predictive mean matching method were compared to the PISA 2012 Turkish data in order to overcome missing data problem. Predictive mean matching, unlike other imputation methods, uses linear regression not to generate imputed values. Rather, it builds a construct metric for matching cases with missing data to similar cases with original data (van Buuren and Groothuis-Oudshoorn, 2011).

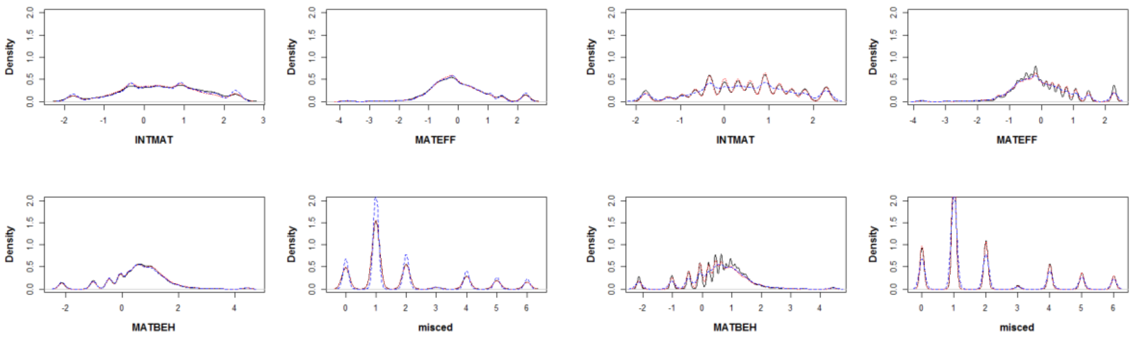

Figure 2: Comparison of Kernel Density Plots of Selected Items for Single and Five Imputations

In this research all the questionnaire items and estimated indices are implemented at the same time by using predictive mean matching (pmm) with single and five imputations. All the missing data were imputed using the "mice" package (van Buuren & Groothuis-Oudshoorn, 2011) in R (R Core Team, 2014). Figures 2 displays the kernel density plots of the selected items using *pmm* for single imputation (the graph on left) and five imputations (the graph on right), respectively. In Figure 2 for single imputation, all the densities of imputed values using *pmm* are closer to the densities of the observed values compared.

Similarly, Figure 3 compare Q-Q plots of selected variables of imputed data. Single imputation Q-Q plots for item-index data has unbiased estimations rather than five imputations when compared to original data. This research uses the single imputed data for further analysis.

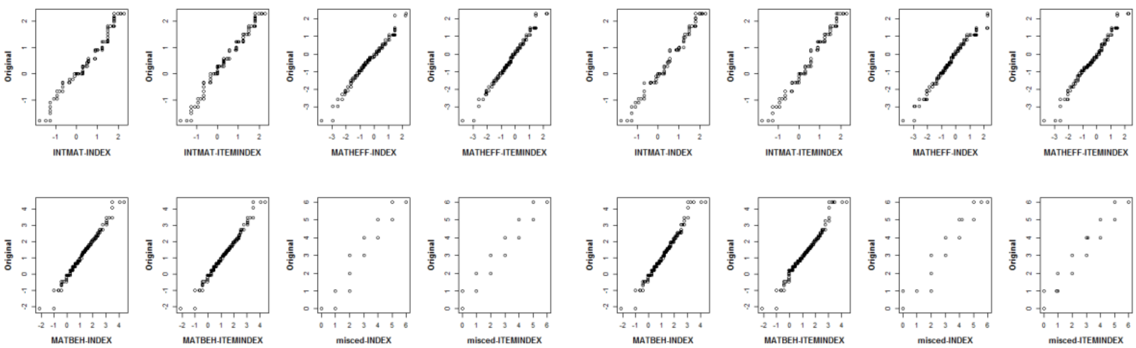

Figure 3: Comparison of Q-Q Plots of Selected Items for Single and Five Imputations

2.4. Statistical Analysis

This study employed hierarchical linear modeling (HLM) as a more appropriate method for analyzing PISA data which students are nested within schools (Raudenbush & Bryk, 2002) in order to examine the effects of student and school factors on mathematics achievement at both student and school levels. HLM accommodates some of the variance among students attending the same school, capturing differences in mathematics achievement among schools as well as between students

2.4.1. Model 1

Model 1 is technically the Null model which is the simplest of the models and called the fully unconditional model. It basically separates total variance into variance due to student level and variance due to school level.

Student Level (Level 1): $MATHACH_{ij} = \beta_{0j} + r_{ij}$

School Level (Level 2): $\beta_{0j} = \gamma_{00} + u_{0j}$

The variance of outcome variable is equal to the sum of between variability (τ_00) and within variability (σ^2). Null model also allows to calculate proportion of variance that is attributable to school level, which is named intraclass correlation:

$$\rho = \frac{\tau_{00}}{\tau_{00} + \sigma^2}$$

2.4.2. Model 2

Model 2 is the extent of Model 1 and named Random Coefficient Model. Random Coefficient Model includes a covariate at student level with a random effect which has different effects on school level variables.

Student Level (Level 1):

$$\begin{aligned} MATHACH_{ij} = {} & \beta_{0j} + \beta_{1j}(ANXMAT) + \beta_{2j}(ENTUSE) + \beta_{3j}(ESCS) + \beta_{4j}(EXPUREM) \\ & + \beta_{5j}(FAILMAT) + \beta_{6j}(FAMCON) + \beta_{7j}(FAMCONC) + \beta_{8j}(HEDERS) \\ & + \beta_{9j}(ICTATTNE) + \beta_{10j}(ICTRES) + \beta_{11j}(MATHEFF) + \beta_{12j}(MATINTFC) \\ & + \beta_{13j}(OPENPS) + \beta_{14j}(SCMAT) + \beta_{15j}(SUBNORM) + \beta_{16j}(TCHBEHSO) + r_{ij} \end{aligned}$$

School Level (Level 2):

$$\begin{aligned} \beta_{0j} &= \gamma_{00} + u_{0j} \\ \beta_{1j} &= \gamma_{10} + u_{1j} \\ & \vdots \\ \beta_{16j} &= \gamma_{160} + u_{16j} \end{aligned}$$

2.4.3. Model 3

The final model, Intercepts-and-Slopes-as-Outcomes Model, allows to model the variability of the regression coefficient using both intercepts and slopes (Raudenbush and Bryk, 2002).

Student Level (Level 1):

$$\begin{aligned} MATHACH_{ij} = {} & \beta_{0j} + \beta_{1j}(ANXMAT) + \beta_{2j}(ENTUSE) + \beta_{3j}(ESCS) + \beta_{4j}(EXPUREM) \\ & + \beta_{5j}(FAILMAT) + \beta_{6j}(FAMCON) + \beta_{7j}(FAMCONC) + \beta_{8j}(HEDERS) \\ & + \beta_{9j}(ICTATTNE) + \beta_{10j}(ICTRES) + \beta_{11j}(MATHEFF) + \beta_{12j}(MATINTFC) \\ & + \beta_{13j}(OPENPS) + \beta_{14j}(SCMAT) + \beta_{15j}(SUBNORM) + \beta_{16j}(TCHBEHSO) + r_{ij} \end{aligned}$$

School Level (Level 2):

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(MACTIV) + \gamma_{02}(PROMATH) + \gamma_{03}(SCMATEDU) + \gamma_{04}(STRATIO) + \gamma_{05}(STUDCLIM) + u_{0j}$$

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

$$\vdots$$

$$\beta_{16j} = \gamma_{16.0} + u_{16j}$$

3. FINDINGS

Table 1 presents the descriptive statistics for the student level, school level and outcome variables. Most OECD questionnaire scale indices are standardized with a mean of 0 and standard deviation of 1 for all student population of OECD countries. Thus, negative value indicates that Turkish students responded less positively than the average response across OECD.

Table 1: Descriptive Statistics for Selected Variables

Variables	N	Mean	SD
Student Level			
Mathematics Anxiety (ANXMAT)*	4236	.25	1.02
ICT Entertainment Use (ENTUSE)*	4236	-.38	1.33
Index of economic, social and cultural status (ESCS)*	4236	-1.38	1.09
Experience with Pure Mathematics Tasks at School (EXPUREM)*	4236	-.07	1.07
Attributions to Failure in Mathematics (FAILMAT)*	4236	.25	1.06
Familiarity with Mathematical Concepts (FAMCON)*	4236	.48	.81
Familiarity with Mathematical Concepts (Signal Detection Adjusted) (FAMCONC)*	4236	.12	1.03
Home educational resources (HEDRES)*	4236	-.52	1.05
Attitudes Towards Computers: Limitations of the Computer as a Tool for School Learning (ICTATTNEG)*	4236	.17	1.12
ICT resources (ICTRES)*	4236	-1.33	1.19
Mathematics Self-Efficacy (MATHEFF)*	4236	.01	.93
Mathematics Intentions (MATINTFC)*	4236	.18	.96
Openness for Problem Solving (OPENPS)*	4236	.22	.95
Mathematics Self-Concept (SCMAT)*	4236	-.05	.97
Subjective Norms in Mathematics (SUBNORM)*	4236	.26	1.10
Teacher Behavior: Student Orientation (TCHBEHSO)*	4236	.30	1.03
School Variables			
Mathematics Extracurricular activities at school (MACTIV)*	128	1.81	1.33
Proportion of mathematics teachers (PROMATH)	120	.12	.04
Quality of school educational resources (SCMATEDU)*	128	-.03	.90
Student-Teacher ratio (STRATIO)	121	16.57	6.92
Student-Related Factors Affecting School Climate (STUDCLIM)*	128	-.02	1.08
Outcome Variables			
PV1MATH	4236	456.38	93.84
PV2MATH	4236	456.52	93.58
PV3MATH	4236	456.53	93.17
PV4MATH	4236	457.36	93.60
PV5MATH	4236	457.55	93.54

*Indices standardized (μ=0, σ=1)

Based on descriptive statistic it is obvious that Turkish schools are slightly under the OECD average except for extracurricular mathematics activities which is significantly above the OECD average. For student level indices, economic and socio-economic status (ESCS) and ICT resources (ICTRES) are significantly under the OECD average. The descriptive statistic and additional central tendency statistic (skewness and kurtosis) both indicate that five plausible values of mathematics achievement are roughly normally distributed (Skewness Max=.415, Min=.381; Kurtosis Max=-.244, Min=-.293).

All factors were analyzed using HLM to explore their associations with mathematics achievement in PISA 2012. Table 2 presents the results of HLM results for null model, random coefficient model and intercepts-and-slopes-as-outcomes model. Average school mean mathematics achievement was statistically different from zero (γ_{00}=454.732, *p*=0.000). Given the mean and variance a confidence interval was calculated to describe a range that includes 95% of all schools' average mathematics achievement (CI= 454.732±1.96 $(6.662)^{1/2}$). With 95% confident the mean mathematics achievement mean is between 441.67 and 469.36. For the variance in school means τ_{00}=5584.54, *p*=0.000, so there were considerable variations in the school means. Interclass correlation coefficient (ICC) (ρ= τ_{00} / ($\tau_{00} + \sigma^2$) = 5584.546 / (5584.546+ 3160.658) =0.64) indicates that 64 % of the variability in mathematics achievement was between schools (remaining 46 % of variability within school). It implies that, on average, mean mathematics achievement of Turkish schools vary heterogeneously between schools. Thus, additional student-level variables were added to try to reduce the variance within schools and the school-level predictors were added in order to explain between-school variance in the Model 2 and Model 3.

Table 2: Fixed Effects Estimates and for Models of the PISA 2012 Mathematics Achievement

Fixed Effects	Model 1			Model 2			Model 3		
	Coeff	SE	p	Coeff	SE	p	Coeff	SE	p
Intercept, γ_{00}	454.732	6.662	<0.001	454.722	6.661	0.000	456.34	5.234	0.000
Student Level									
(ANXMAT, γ_{10}				-4.312	0.912	0.000	-4.608	0.854	0.000
ENTUSE, γ_{20}				3.639	0.691	0.000	4.028	0.733	0.000
ESCS, γ_{30}				3.799	1.125	0.001	3.504	1.113	0.002
EXPUREM, γ_{40}				3.407	0.893	0.000	4.359	0.856	0.000
FAILMAT, γ_{50}				-1.931	0.861	0.027	-1.812	0.894	0.042
FAMCON, γ_{60}				4.453	1.131	0.000	3.591	1.095	0.002
FAMCONC, γ_{70}				5.698	0.898	0.000	5.404	0.853	0.000
HEDRES , γ_{80}				3.515	1.358	0.011	4.5	1.424	0.002
ICTATTNEG, γ_{90}				-4.743	0.805	0.000	-5.099	0.777	0.000
ICTRES, γ_{100}				-2.714	1.187	0.024	-3.103	1.175	0.009
MATHEFF, γ_{110}				8.707	1.011	0.000	8.659	0.947	0.000
MATINTFC, γ_{120}				2.132	0.915	0.021	2.461	0.888	0.006
OPENPS, γ_{130}				3.872	0.926	0.000	4.286	0.894	0.000
SCMAT, γ_{140}				3.776	1.081	0.001	3.595	1.101	0.001
SUBNORM, γ_{150}				-3.757	0.889	0.000	-4.225	0.837	0.000
TCHBEHSO, γ_{160}				-5.767	0.866	0.000	-5.622	0.781	0.000
School Variables									
MACTIV, γ_{01}							9.990	4.377	0.024
PROMATH, γ_{02}							457.72	21.938	0.000
SCMATEDU, γ_{03}							12.123	5.877	0.041
STRATIO, γ_{04}							-2.501	0.829	0.004
STUDCLIM, γ_{05}							19.132	5.599	0.001

Intercept variance, τ_{00}	5584.54	5603.14	3122.40
Level 1 variance, σ^2	3160.65	2509.47	2733.63
Intraclass correlation, ρ	.64	.69	.53
Between-school variance explained (%)	-	1%	44%
Within-school variance explained (%)	-	21%	13%

The results based on Model 2 shows that after including 16 variables as a student-level predictors of mathematics achievement within school, within school variability reduced by 21% (3160.658-2509.471)/3160.658 =0.206), relative to the null model. Overall mean mathematics achievement across schools was still significantly different from zero (γ_{00}=454.722,*p*=0.000). The average effects of all student-level variables on mathematics achievement was significant. The largest effect has been found on mathematics self-efficacy scores. For each unit increase in students' mathematics self-efficacy, there were average 8.707 points increase in mathematics scores in PISA 2012 across schools. For mathematics anxiety, attributions to failure in mathematics, attitudes towards computers: limitations of the computer as a tool for school learning, ICT resources, subjective norms in mathematics and teacher behavior: student orientation variables there also had significant negative effects on mathematics achievement. That mean one unit change in these variables decreases mathematics scores in PISA 2012 across schools. Specifically, for each unit change in students' attitudes towards computers could decrease 4.743 points of mathematics scores in PISA 2012 across schools. Table 3 summarizes the random effects for each model. Table 3 shows that at school-level it has been found that there was a significant variation in school means in familiarity with mathematical concepts variable. That means the effect of familiarity with mathematical concepts variable was not same across schools in mathematics achievement.

Table 3: Random Effects Estimates and for Models of the PISA 2012 Mathematics Achievement

Random Effects	Model 1			Model 2			Model 3		
	Variance	SD	p	Variance	SD	p	Variance	SD	p
Level 1 Error, r_{0j}	3160.65	56.22	0.000	2509.47	50.09		2733.63	52.28	
Level 2 Error, u_{0j}	5584.54	74.73					3122.40	55.87	0.000
Student Level									
ANXMAT				7.261	2.695	0.382			
ENTUSE				3.787	1.946	>.500			
ESCS				25.492	5.049	0.161			
EXPUREM				20.581	4.537	0.177			
FAILMAT				16.797	4.098	>.500			
FAMCON				**14.837**	**3.852**	**0.032**	5.009	2.23	0.116
FAMCONC				9.985	3.160	>.500			
HEDRES				57.543	7.586	0.051			
ICTATTNEG				10.779	3.283	0.134			
ICTRES				26.424	5.140	0.242			
MATHEFF				11.270	3.357	0.405			
MATINTFC				12.146	3.485	0.195			
OPENPS				7.130	2.670	>.500			
SCMAT				36.894	6.074	0.413			
SUBNORM				25.636	5.063	0.178			
TCHBEHSO				10.600	3.256	>.500			

Model 3 provides both student-level and school-level predictors for mathematics achievement. In this model intercept was treated as random with school-level predictors, and the remaining coefficients were specified as fixed. Relative to the null model, 44.1% of the variance in the between school difference in mean mathematics achievement was accounted by mathematics extracurricular activities at school, proportion of mathematics teachers, quality of school educational resources, student-teacher ratio and student-related factors affecting school climate (σ^2 (Model 1)-σ^2 (Model 3)/σ^2 (Model 1) =44.1%). Overall mean mathematics achievement across schools was also remained significant from zero (γ_{00}=456.34, *p*=0.000). After controlling for other school-level variables there was a significant negative difference in mathematics achievement between schools with high student-teacher ratio and low student-teacher ratio (γ_{04}=-2.501, *p*=0.004). The schools with low student-teacher ratio has more qualified in mathematics achievement rather than high student-teacher ratio. After controlling rest of school-level variables proportion of mathematics teachers had the largest significant effect on mathematics achievement between schools (γ_{02}=457.77, *p*=0.000). This result shows that the amount of mathematics teachers in any school had the largest affect in mathematics achievement in PISA 2012. Schools with more mathematics teachers tend to increase mathematics achievement in PISA 2012 after controlling other school-level variables.

4. DISCUSSION and RESULTS

By way of HLM analyses at student and school levels, this study has emphasized the most important factors affecting the mathematics achievement of Turkish students in PISA 2012. The results of Model 1 indicate that 64 % of the variability in mathematics achievement was found between schools. Thus, adding student-level variables could help to clarify variability within schools. At student level factors, it has been found that there are consistent results with prior research. Variables associated with attitudes towards mathematics have significant effects on mathematics achievement. Mathematics self-efficacy has the most significant impacts on mathematics achievement after controlling remaining variables are taken into account. Consistent with previous researches (Güzel & Berberoğlu, 2010; Anderson, Milford, & Ross, 2009) there is a positive and significant relationship between mathematics self-efficacy and mathematics achievement. After controlling remaining variables, one-unit increase in mathematics self-efficacy has increased mathematics achievement average 8 points in both Model 2 and Model 3. Mathematics anxiety is another variables determining attitudes towards mathematics. Unfortunately, In Model 2 and Model 3, it's been found that mathematics anxiety has negative significant effect on mathematics achievement. After controlling remaining variables, one-unit increase in mathematic anxiety decrease mathematics achievement, respectively. Findings are consistent with prior researches (Güzel & Berberoğlu, 2010; Koğar, 2015; Uysal, 2015). Uysal (2015) also has found that mathematics anxiety had negative and medium effect on mathematics achievement.

The index of subjective norms in mathematics has a negative effect on mathematics achievement which is mostly related to perceptions of family and friends. According to the findings of this study, it is found that there is a gap between student-related attitudes and environment related factors with respect to attitudes towards mathematics. Factors related external variables, such as subjective norms in mathematics and mathematics anxiety have negative effects on mathematics achievement. Contrary, factors mostly related students' belief, awareness and intension have positive effects on mathematics achievement.

Delen and Bulut (2011) suggested that technology usage at school was found to be a weak predictor of mathematics achievement. In that research, generally speaking, ICT family variables have negative effect on mathematics achievement except for ICT entertainment use. Students' use of ICT for entertainment purposes has positive effects on their mathematics achievements which is consistent with the study of Skryabin, Zhang, Liu, and Zhang (2015). After all, adding 16 student-level variables helped to explain %21 of variability within schools.

For the school-level variables, proportion of mathematics teachers was found to be a strong predictor of a school's average mathematics achievement. Mathematics extracurricular activities at school, quality of school educational resources, student-related factors affecting school climate are the variables that associate with better performance at school-level. However, it's been found that student-teacher ratio was the only negative predictor of mathematics achievement at school-level. The results show that attendance in extracurricular activities had a positive effect on students' mathematics achievement. Prior research concluded that this relationship is common in literature and at the school level, better educational resources could improve average school mathematics achievement (Schuepbach, 2015; Shelley and Su, 2011).

It's been found that only student-teacher ratio variable has negative effect on mathematics achievement. More likely the schools with a higher student-teacher ratio has lower mathematics achievement because of overcrowded classroom. This results are expected especially when proportion of mathematics teachers' variable has the largest effect on mathematics achievement at school-level. These two variable show somewhat consistency across Model 3 results. As a conclusion, all these school-levels explained 44.1% of the variance in the between school difference in mean mathematics achievement.

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Uzun Özet

Ekonomik İşbirliği ve Kalkınma Teşkilatı - OECD (Organization of Economic Cooperation and Development) tarafından finanse edilen Uluslararası Öğrenci Değerlendirme Programı – PISA (The Programme for International Student Assessment), üç yılda bir OECD üye ve üye olmayan bazı ülkelerin katılımı ile 2000 yılından itibaren uygulanmaktadır. PISA, 15 yaş grubu öğrencilerin matematik, fen ve okuma becerilerini günlük hayatta karşılaştıkları problemlerin çözümünde nasıl kullandıklarını ölçen bir uygulamadır. Bu nedenle; ülkelerin kalkınmasına katkı sağlayacak genç nüfus hakkında ciddi veriler sağlamaktadır. Elde edilen veriler çeşitli araştırmalara konu olup farklı şekillerde kullanılabilir. PISA verileri ile ülkelerin eğitim politikalarına yön verecek, veriye dayalı kararların alınması bir ülkenin geleceğine dair önemli bir katkıdır.

Türkiye PISA uygulamasına ilk olarak 2003 yılında katılmış ve sürekli katılımı devam etmektedir. Ülkemizin PISA uygulamalarında gösterdiği performanslar incelendiğinde; yıllara göre artan bir başarıya sahip olmasına rağmen halen OECD ortalamasının altında yer aldığı görülmektedir. Performansa etki eden faktörlerin incelenmesi, Türk eğitim sistemine getireceği katkıları sebebiyle büyük önem teşkil etmektedir. Bu sebeple, PISA 2003 uygulamasından itibaren ulusal alan yazında çeşitli araştırmalarla okuma becerisi, matematik okuryazarlığı ve fen okuryazarlığı performansları incelenmekte ve çeşitli öneriler sunulmaktadır.

İlgili çalışmalara bakıldığında performanslara etki eden değişkenlerin genel olarak tek düzeyde ele alındığı görülmüştür. Bu çalışmada ise, PISA 2012 uygulamasına katılmış olan Türk öğrencilerin matematik performansına etki eden değişkenlerin okul ve öğrenci düzeylerinde incelenmesi amaçlanmıştır. Bu amaç doğrultusunda PISA 2012 öğrenci anketi ve okul anketlerinde yer alan ve alan yazında matematik performansına etkisi olduğu düşünülen değişkenler ele alınarak ilişkisel bir desen oluşturulmuştur.

Matematik performansına etkisi olduğu düşünülen değişkenleri okul düzeyinde 25 indeks, öğrenci düzeyinde ise 37 indeks oluşturmaktadır. Bu indekslerin matematik performansına olan etkilerinin incelenmesi için Hiyerarşik Lineer Model (HLM) analiz yöntemi kullanılmıştır. HLM yöntemi ile hem öğrenci ve okul düzeyindeki değişkenlerin performansa olan etkisi hem de okullar arasındaki farklılıklardan kaynaklı olan başarı değişiklikleri incelenmiştir. Analize başlamadan önce PISA 2012'ye katılmış olan 170 okuldan 4848 öğrencinin verileri ile iki düzeyli HLM varsayımları test edilmiştir. Varsayımların test edilmesi sonucunda analiz 128 okuldan 4326 öğrenci verisi kullanılarak yapılmıştır.

PISA 2012 uygulamasında, daha önceki PISA uygulamalarından farklı olarak, öğrenci anketinde farklı desenler kullanılmış ve 3 farklı anket kitapçığı oluşturulmuştur. Daha az soru ile daha fazla veri elde etme amacıyla yapılan bu desenleme sonucunda ciddi bir kayıp veri sorunu ortaya çıkmıştır. Bu kayıp veri sorununu giderebilmek için yordayıcı ortalama eşleşme (pmm) yöntemi kullanılarak tüm anket maddeleri ve indeksler aynı anda uygulanmıştır. Kayıp verilerin giderilmesi için R yazılımında "mice" paketi kullanılmıştır. Kernel yoğunluk grafikleri ve Q-Q grafikleri incelerek kayıp verilerin giderilmesi için tek bir uygulamanın (imputatiton) yeterli olduğuna karar verilmiştir.

Analiz sonucunda okul düzeyinde 5 indeksin (Okulda ders programı dışındaki matematik aktiviteleri (MACTIV), Matematik öğretmenlerinin oranı (PROMATH), Okuldaki eğitimsel kaynakların kalitesi (SCMATEDU), Öğretmen-öğrenci oranı (STRATIO), Öğrenci-okul iklimini etkileyen ilişkili faktörler (STUDCLIM)), öğrenci düzeyinde ise 16 indeksin (Matematik kaygısı (ANXMAT), Bilgi ve İşlem Teknolojisinin (BİT) eğlence için kullanımı (ENTUSE), Ekonomik, sosyal ve kültürel statünün indeksi (ESCS), Okuldaki matematik görevleri deneyinimi (EXPUREM), Matematik başarısızlığı (FAILMAT), Matematiksel kavramlara aşinalık (FAMCON), Ayarlanmış matematiksel kavramlara aşinalık (Signal Detection Adjusted) (FAMCONC), evdeki eğitimsel kaynaklar (HEDRES), Bilgisayara yönelik tutumlar: bir araç olarak bilgisayarın okul öğrenmeleri için sınırlamaları (ICTATTNEG), BİT kaynakları (ICTRES), Matematik özyeterliliği (MATHEFF), Matematiğin amacı (MATINTFC), Problem çözmeye açıklık (OPENPS), Matematik benlik kavramı (SCMAT), Matematikteki öznel normlar (SUBNORM), Öğretmen davranışı: öğrenci oryantasyonu (TCHBEHSO)) matematik performansını anlamlı bir şekilde etkilediği sonucu elde edilmiştir.

İki düzeyli HLM analizi ile 3 model elde edilmiştir. Model 1’in sonucuna göre; matematik başarısındaki değişkenliğin %64’ü okullardan kaynaklanmaktadır. Bu sebeple öğrenci düzeyindeki değişkenlerin eklenmesi ile okul içindeki değişkenliğe bir açıklık getirilmiştir. Matematiğe karşı tutumla ilişkili olan değişkenler matematik başarısı üzerinde önemli bir etkiye sahiptir. Analizde kalan değişkenler kontrol edildikten sonra matematik öz yeterliğinin matematik başarısı üzerinde en önemli etkiye sahip olan değişken olduğu görülmüştür. Matematik öz yeterliğindeki bir birimlik artışın, hem Model 2 hem de Model 3’te ortalama 8 puanlık bir artış sağladığı sonucu elde edilmiştir. Matematik kaygısı hem Model 2 hem de model 3’te matematik başarısını olumsuz yönde etkilemiştir. Kalan değişkenler kontrol edildikten sonra matematik kaygısındaki bir birimlik artış matematik başarısını düşürmüştür.

Öğrenci düzeyindeki 16 değişkenin modele eklenmesiyle okullar içindeki değişkenliğin %21’i açıklanmıştır. Okul düzeyindeki değişkenler için, matematik öğretmenlerinin oranı okulun ortalama başarısı için güçlü bir yordayıcı olarak bulunmuştur. Okulda ders programı dışındaki matematik aktiviteleri, okuldaki eğitim kaynaklarının kalitesi ve öğrenci-okul iklimini etkileyen ilişkili faktörler, okul düzeyinde daha iyi bir performans sağlanması ile ilişkili olan değişkenler olmuştur. Öğrenci-öğretmen oranının okul düzeyinde matematik başarısının tek negatif yordayıcısıdır.

Sadece öğrenci-öğretmen oranı değişkenin matematik başarısı üzerinde olumsuz etkiye sahip olduğu tespit edilmiştir. Büyük olasılıkla daha yüksek bir öğrenci-öğretmen oranına sahip okullarda sınıfların kalabalık olması sebebiyle daha düşük bir matematik başarısı vardır. Model 3’e bakıldığında tüm bu okul düzeylerinin ortalama matematik başarısının okullar arasındaki farkın varyansının %44,1’ini açıklamıştır.