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How does the ICT Access and Usage Influence Student Achievement in PISA 2009 and 2012? *

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Abstract
The purpose of this study is to investigate the effects of access and usage of information and communication technologies (ICT) on Turkish students' mathematics achievement implemented in PISA 2009 and PISA 2012. A correlational research model was used in this study. In this study, the data which were obtained from the PISA 2009 and PISA 2012 mathematics achievement tests and from the information and communications technologies familiarity questionnaire (ICTFQ) in Turkey were used. In this study, three student level variables and two school variables of ICTFQ which are common indexes both in PISA 2009 and PISA 2012 were selected to compare the effect of ICT variables on PISA mathematics achievement implemented in different years. Two-level Hierarchical Linear Modeling (HLM) analysis was performed in the analysis of the data. As a result, the student level variables had a small or a trivial effect on mathematics achievement. The effect size value of the ENTUSE variable was similar in the PISA 2009 and the PISA 2012 implementation, but the effect size value of the HOMSCH variable and the ICTHOME variable on mathematics achievement in PISA 2012 was lower than in PISA 2009. The ICTSCH and the USESCH variables at the school level had a large effect on mathematics achievement in two implementations of PISA 2009 and PISA 2012. The effect size value of the ICTSCH variable on mathematics achievement in PISA 2012 was higher than in PISA 2009. The effect size value of the ICTSCH variable, having a negative relationship with mathematics achievement in PISA 2012, was lower than in PISA 2009. In this study, the explained variance ratio of mathematics achievement by the school ICT variables level was greater than by the student ICT variables level.

Key Words: Information and Communication Technologies (ICT), mathematics achievement, PISA 2009, PISA 2012, two-level hierarchical linear models.

INTRODUCTION

Today, the perspective of learning mathematics has been involved five standards which are related to conceptual understanding, problem solving, mathematical thinking and reasoning, communicating, making realistic plans for the future and applying these plans (National Council of Teachers of Mathematics-NCTM, 2000, 2014). This viewpoint is consistent with PISA (Programme for International Student Assessment) mathematics literacy defined by OECD (Organization for Economic Cooperation and Development) (2013, 2017) as "using mathematical concepts, processes, and devices to define, explain and guess reasoning mathematically." (p. 17, p. 15). However, mathematics, consisting of sequential abstractions and generalization processes of various structures and connections (Alakoç, 2003), is one of the aspects of lessons which makes learning and comprehension skills difficult for students (Akın & Cancan, 2007; Alakoç, 2003; Murphy, 2016). Technology is one of the applications that will enable students to understand mathematics and to see the usage of mathematics in real life properly (Murphy, 2016). "The information and communication technologies (ICT) include the usage of dynamic mathematics/geometry software, Excel program, manipulative geometric shapes, internet resources (web site, animation, tutorial web applications, video, etc.)" (Ural 2015, p. 94) for developing mathematical teaching. These information and communication technologies contribute to students to learn mathematical concepts easily, to concrete

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the concepts, to solve the problems, to think critically and creatively (Alakoç, 2003; Barkatsas, Kasimatis, & Gialamas, 2009; Jang 2009; Lazakidou & Retails 2010; McMahon 2009; Murphy, 2016; Pamuk, Çakır, Ergun, Yılmaz, & Ayas, 2013; Shaikh & Khoja, 2011; Ural, 2015; Yorgancı & Terzioğlu, 2013; Yusuf & Afolabi, 2010; Zengin, Kağızmanlı, Tatar, & İşleyen, 2013). The information and communication technologies are important for using in mathematical teaching because of these features (Ural 2015). Also, the usage of the information and communication technologies are included in the curriculum of elementary school mathematics lessons which were updated in 2013 by the Ministry of National Education in the context of Turkey (Ministry of National Education-MEB, 2013a).

Many countries have heavily invested in ICT infrastructure to adopt implementing ICT-related policies (De Witte & Rogge, 2014; Skryabin, Zhang, Liu, & Zhang, 2015). The reason for adopting ICT-related policies for usage of ICT in education is to improve students' 21st-century competencies (Anderson, 2008; Kim, Kil, & Shin, 2014; Scheuermann & Pedró, 2009). Due to the importance of the integration of ICT into education, the OECD also conducts various studies on the usage of ICT at the international level. The goal of these studies is to evaluate the education policies of countries and to compare them with each other (Bilican-Demir & Yıldırım, 2016). PISA is one of the large-scale assessments to evaluate students' knowledge and skills at the national and international level (OECD, 2014b). Also, PISA examines the causes and factors affecting the student's achievement at national and international levels and provides scientific data for evaluating curriculum and designing appropriate educational settings (Acar, 2012; Bilican-Demir & Yıldırım, 2016).

Recently, especially the studies of the relationship between ICT and academic achievement have increased in large-scale international assessments (OECD, 2014b; Skryabin, et al., 2015; Şengül & Demir, 2018). When the studies are reviewed to determine the relationship between ICT-based learning, teaching, and achievement, it has been especially found that there is an inconclusive relationship between ICT and mathematics achievement. Also, the results of different studies are inconsistent with one another. It was concluded that there was little evidence of the impact of ICT on achievement, and limited comparability on the large-scale assessments (Balanskat, Blamire, & Kefala, 2006; Cox & Marshall, 2007; De Witte & Rogge, 2014; Skryabin et al., 2015; Trucano, 2005). Although digital technologies are claimed to be important in the 21st century, some doubts have occurred that more or better ICT means better education (Livingstone, 2012). Pandolfini (2016) concluded that the majority of the studies are related to the impact of ICT and are figured out simple outcomes on the individual level, such as only teachers or students. In recent years, the tendency has been argued that the impact of ICT is highly complicated. In order to interpret the effects of ICT in education, more information is needed about how ICT operates at different levels (such as teacher, student, school, and parent) and what levels are measured (Erstad, 2009). The ICT-related research needs to be synthesized from a holistic perspective (Sutherland, Robertson, & John, 2009).

The studies of multilevel approaches to how the impact is interrelated on different levels, and to clarify the effects of ICT usage are becoming important (Pandolfini, 2016). This study focused on different levels of students and schools for the impact of ICT on students' mathematics achievement. One data set of PISA was used in the majority of studies to determine the effect of ICT on PISA mathematics achievement. For instance, Demir and Kılıç (2009) and Güzeller and Akın (2014) used PISA 2006 dataset, Delen and Bulut (2011) assessed PISA 2009 dataset, Wittwer and Senkbeil (2008) examined PISA 2003 dataset and Petko, Cantieni and Prasse (2017) investigated PISA 2012 dataset in their studies. One reason for this can be that one of science, reading and mathematics is chosen as the major domain in each assessment, and so the focused domain varies with each PISA implementation. The major domain is assessed more; the other two domains are minor domains and assessed less thoroughly. It is important to remember that these three domains are measured in every implementation of PISA. There are fewer studies which are related to the relationship between student and school characteristics and PISA mathematics achievement implemented in different years (e.g., Karabay, Yıldırım, & Güler, 2015). It can be said, according to our knowledge, that there are insufficient studies in literature on examining how the student and school level of ICT variables affect PISA mathematics achievement implemented in 2009 and in 2012.

This study focused on examining the effect of ICT variables on students' mathematics achievement in both PISA 2009 and PISA 2012 and comparing the predictive level of ICT variables on students' PISA mathematics achievement implemented in 2009 and in 2012. In PISA 2009, just five of seven scaled indexes ICT-related aspects for the information and communication technologies familiarity questionnaire (ICTFQ) were used in this study. In PISA 2012 ICT familiarity questionnaire, just five of eight scaled indexes ICT-related aspects were used in this study. The ICT variables are grouped into student level and school level in this study. The student level ICT variables are the ICT availability at home (ICTHOME), the ICT use for entertainment (ENTUSE), and the ICT use at home for school-related tasks (HOMSCH). The school level ICT variables are the ICT availability at school (ICTSCH) and the ICT use at school (USESCH). These three student level variables and two school variables of the ICTFQ, which are common in both PISA 2009 and PISA 2012, were selected in this study to compare the effect of ICT variables on PISA mathematics achievement implemented in 2009 and 2012. These student level and school level ICT variables are the common variables in both PISA 2009 and PISA 2012 ICTF questionnaire (OECD, 2012; OECD, 2014c). The reason for the selection of these variables is to compare two implementations of PISA which are PISA 2009 and PSA 2012.

This study will contribute to the following gaps in the literature: (a) ICT is constantly evolving, and its impact is difficult to isolate from the environment (Youssef & Dahmani, 2008). This research may contribute to the literature to clarify the impact of the level of access and usage of ICT on mathematics achievement. (b) As far as we investigate, there is a dearth of studies in the literature on comparing the explained variance ratio in mathematics achievement caused by ICT variables in two different implementations of PISA. In this study, the explained variance ratio in mathematics achievement in 2009 and 2012 caused by ICT variables was compared. The disclosure variance ratio could be given an idea about the effective usage of ICT in mathematics education by years because of changing the usage of ICT continuously over the years. (c) In this research, hierarchical linear models have been established. Considering the structure of the PISA dataset, it can be said that since the hierarchical models have calibrated the estimated standard error better, it started to become important to interpret the findings with less errors in order to reach more accurate results. (d) While the major domain was mathematics in PISA 2012, the domain of reading was given greater emphasis on PISA 2009. This study will provide an opportunity to interpret how the effect of ICT variables on mathematics achievement changes depending on the domain. Thus, this study aims to present a holistic perspective on the effect of ICT on mathematics achievement.

Purpose of the Study

This research aimed to investigate the impact of access and usage of ICT at both student variables and school variables on Turkish students' mathematics achievement in PISA 2009 and PISA 2012. The problem of this study is to examine the ratio of variance explained in mathematics achievement caused by the access and usage of ICT in PISA 2009 and PISA 2012 implementations. The research questions of this study are as follows:

1. What is the explained variance ratio in mathematics achievement caused by the difference among students and between schools according to PISA 2009 and 2012 data in Turkey?
2. What is the explained variance ratio in mathematics achievement caused by the variables regarding the access and usage of ICT at student level according to PISA 2009 and 2012 data in Turkey?
3. What is the ratio of variance explained in mathematics achievement caused by the variables related to ICT both at school level and at student level according to PISA 2009 and 2012 data in Turkey?

METHOD

This study was established on the correlational model. This research method is used to examine whether a relationship among two or more variables. The purposes of correlation model is to explore the phenomena and to make predictions by identifying relationships among variables (Fraenkel, Wallen, & Hyun, 2011).

Sample

The sample of this research consisted of a student group at the age of 15 having participated in PISA 2009 and PISA 2012 (MEB, 2010, 2013b). The sample design was a two-stage stratified sample design according to the PISA. The first-step sampling units involved in schools having 15-year-old students. The second-step sampling units included students within sampled schools. The sample consisted of 4996 students who participated in the PISA 2009 survey (OECD, 2012) and 4848 students who participated in the PISA 2012 survey (OECD, 2014b).

Data Collection Instruments

The data obtained from the mathematics achievement of students in PISA 2009 and PISA 2012, and the common indexes in the ICTFQ in PISA 2009 and 2012 were used in this study. The mathematics achievements of students in PISA 2009 and 2012 were calculated by using the generalized form of the Rasch model (OECD, 2014a). PISA mathematics performance was reported as five plausible variables (PVs) calculated using the one-parameter (Rasch) model for dichotomous items for each student in the sample. The PVs are random and draw from the marginal posterior distribution in PISA. PV1MATH, PV2MATH, PV3MATH, PV4MATH, and PV5MATH are the variables for mathematical literacy. Since the correlation between these plausible values is high, the PV1MATH randomly selected was used in this study. The value of the reliability of PISA 2009 mathematics domain is .90 (OECD, 2012), and the reliability value for PISA 2012 mathematics domain is .92 for Turkey (OECD, 2014c).

The ICT familiarity questionnaire was administered in both PISA 2009 and PISA 2012 (OECD, 2012, 2014c). The ICT variables are grouped into student level and school level in this study. The student level ICT variables are the ICT availability at home (ICTHOME), the ICT use for entertainment (ENTUSE), and the ICT use at home for school-related tasks (HOMSCH). The school level ICT variables are the ICT availability at school (ICTSCH) and the ICT use at school (USESCH).

In PISA 2009, seven scaled indexes ICT-related aspects were computed for this questionnaire, and five of them were used in this study. The labels of these student level ICT-related indexes are the ICT availability at home (ICTHOME and Cronbach α = .81), the ICT use for entertainment (ENTUSE and Cronbach α = .91) and the ICT use at home for school related tasks (HOMSCH and Cronbach α = .84). The labels of these school level ICT-related indexes are the ICT availability at school (ICTSCH and Cronbach α = .74) and the ICT use at school (USESCH and Cronbach α = .89) (OECD, 2012). ICTHOME variable had eight items in PISA 2009. The eight items provide information on ICT availability of a desktop computer, portable laptop or notebook, internet connection, video games console, cell phone, Mp3/Mp4 player, iPod or similar, printer and USB stick at home. This variable had three response categories which were *Yes, and I use it*, *Yes, but I don't use it* and *No*. ENTUSE variable included eight items. These items give information on the use of ICT and Internet for entertainment such as playing one-player games, playing collaborative online games, using e-mail, chatting online, browsing the internet for fun, downloading music, films, games or software from the Internet, publishing and maintaining a personal website or blog, participating in online forums, virtual communities or spaces. This variable had four response categories varying from *Never or hardly ever*, *Once or twice a month*, *Once or twice a week* to *Every day or almost every day*. The response categories for HOMSCH variable were same as the response categories of the ENTUSE variable. The five items of HOMSCH variable inform on the use of ICT for school related tasks. To browse the Internet for schoolwork, to use e-mail for communication with other students about schoolwork, to use e-mail for communication with teachers and submission of homework or other schoolwork, to download, to upload or to browse material from your school's website (e.g., time table or course materials), to check the school's website for announcements, e.g., absence of teachers are the items of HOMSCH variable. ICTSCH variable had five items. The items were related to the availability of a desktop computer, portable laptop or notebook, internet connection, printer, and USB (memory) stick at school. The response categories for this variable were same as the response categories of the ICTHOME variable. USESCH variable had nine items, such as chatting online, using e-mail at school, browsing the Internet for schoolwork, downloading, uploading, or browsing material from the school's website, posting your work on the school's website, playing simulations at school, etc. These USESCH variable items provide information on student involvement in ICT related tasks at school. The response categories for this variable were same as the response categories of the ENTUSE variable.

Eight scaled indexes ICT-related aspects were computed utilizing the information which was obtained from PISA 2012 ICT familiarity questionnaire, and five of them were used in this study. The labels of these student level ICT-related indexes are the ICT availability at home (ICTHOME and Cronbach α = .78), the ICT use for entertainment (ENTUSE and Cronbach α = .90) and the ICT use at home for school related tasks (HOMSCH and Cronbach α = .86). The labels of these school level ICT-related indexes are the ICT availability at school (ICTSCH and Cronbach α = .75) and the ICT use at school (USESCH and Cronbach α = .89). In PISA 2012, the indexes of the ICTHOME, the ICTSCH and the ENTUSE were revised from 2009, and new items were added. The indexes of the HOMSCH and the USESCH were revised from 2009 (OECD, 2014c). For PISA 2012, ICTHOME variable had eleven items. These items were revised from 2009, and new items were added. The revised items are such as tablet computer, cell phone (without Internet Access), cell phone (with Internet Access), eBook reader. ENTUSE variable had ten items. Some of them were revised from 2009, and new items were added. The examples of the revised items of the ENTUSE variable are reading news on the Internet, obtaining practical information from Internet, uploading your own created contents for sharing. This variable had five response categories varying from *Never or hardly ever, Once or twice a month*, *Once or twice a week Almost every day* to *Every day*. HOMSCH variable for PISA 2012 included seven items. The items of this variable were revised from 2009. Five response categories for this variable were same as the response categories of the ENTUSE variable. Compared to PISA 2009, two new items, which were tablet computer and eBook reader, were added in the ICTSCH variable for PISA 2012, and the other items were revised from 2009. This variable had seven items and three response categories for this variable were same as the response categories of the ICTHOME variable. The items of USESCH variable were modified from 2009. This variable had nine items and five response categories for this variable were same as the response categories of the ENTUSE variable.

These three student level variables and the two school variables of ICT familiarity questionnaire are common indexes both in PISA 2009 and PISA 2012, and these variables were selected in this study to compare the effect of ICT variables on PISA mathematics achievement implemented in different years. For the construct validity of these scales, psychometric techniques such as correlations, confirmatory factor analyses, and Item Response Theory (IRT) scaling were used.

Most questionnaire items were scaled using IRT scaling methodology in PISA. One Parameter (Rasch) model was used for the dichotomous items (1, 0), and the partial credit model was used for items with multiple score categories (e.g., Likert type items). In order to obtain student scores, weighted likelihood estimation was primarily used by estimating international item parameters from the calibration sampling. Weighted likelihood estimations were transformed into an international metrics with an OECD average of 0 and 1 OECD standard deviation of 1, and indexes were obtained (OECD, 2012, 2014a). The data set ware taken from the website of OECD (2018a, 2018b). The data of Turkey were used from the file named INT_STQ09_DEC11 for the PISA 2009 data and from the file named INT_STU12_DEC03 for PISA 2012 data.

Data Analysis

Two level Hierarchical Linear Modelling (HLM) analysis was used (Raudenbush & Bryk, 2002). Since PISA dataset has a hierarchical structure, the student variables were dealt with at level 1, and the school variables were dealt with at level 2. HLM analysis has some assumptions. These were examined separately for PISA 2009 data and PISA 2012 data. One of these assumptions is related to missing value and outliers. Since the rate of missing value is low, missing value methods were utilized in HLM program for the assignment of missing value. Considering the size of sampling, no analysis was performed related to outliers. In order to determine the multicollinearity which is one of the HLM assumptions, the correlation coefficient value between the predictor variables in level 1 (student) and level 2 (school) is estimated. The correlation matrix for the first and second level variables is given in Table 1 (see Appendix).

The correlation coefficient values between student level variables ranged from .30 to .62. The correlation coefficient values between school level variables ranged from .23 to .35. These values were calculated as less than .70 in Table 1. In order to minimize the high correlation between level 1 and level 2 variables, the data are centered in the analysis (Raudenbush & Bryk, 2002). If the intercept variance represents the between group variance in the outcome measure, the data are centered around the group mean. In grand mean centered models, the intercept variance defines the between group variance in the outcome variable adjusted for the level 1 variables (Hofmann & Gavin, 1998). Hence the level 1 variables were centered around the group mean, while the second level variables were centered around the grand mean in this study. In another assumption of HLM, the normality of the errors at the student level and at the school level were analyzed. Histogram and likelihood graphics were obtained for this (P-P plot or Q-Q plot), and these graphics were found to compose 45-degree lines. Thus, the assumption of errors normality of at both levels were met. For the homogeneity of student level variances, H statistics was calculated, and p value was found to be significant. Considering the assumption of independence of errors, intra-school errors in PISA 2009 mathematics achievement were found to be independent of the student level variables (p_{ENTUSE} = 0.444 > .05; $p_{ICTHOME}$ = .418 > .05; p_{HOMSCH} = .825 > .05). Also, the assumption of independence of errors was ensured for PISA 2012 mathematics achievement (p_{ENTUSE} = .253 > .05; $p_{ICTHOME}$ = .133 > .05; p_{HOMSCH} = .211 > .05).

In order to examine the effects of ICT factors at both student and school levels on mathematics achievement, four models were established for both the implementations of PISA 2009 and PISA 2012. Model 1 is called the One-Way Variance Analysis Random Effects Model (also known as Null model). This model was established to answer the first research question. The equation for this model is as Equation 1, Equation 2 and Equation 3.

Level -1 (Student level) Model:

$$(Y_{ij}|M_{2009}/M_{2012}) = \beta_{0j} + r_{ij} \tag{1}$$

Level -2 (School level) Model:

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{2}$$

Combined Model:

$$(Y_{ij}|/M_{2009}/M_{2012}) = \gamma_{00} + u_{0j} + r_{ij} \tag{3}$$

Model 2 is called Random Coefficients Regression Model. This model involves a covariate at student level with a random effect which has different effects on the school level variables. This model was established in accordance with the second research question. The student level variables are allowed to be distributed randomly between schools, but the outcome variables at school level are not added to the model. The equation for this model is as Equation 4, Equation 5 and Equation 6.

Level - 1 (Student level) model:

$$(Y_{ij}|M_{2009}/M_{2012}) = \beta_{0j} + \beta_{1j} * (ENTUSE_{ij}) + \beta_{2j} * (HOMSCH_{ij}) + \beta_{3j} * (ICTHOME_{ij}) + r_{ij} \tag{4}$$

Level - 2 (School level) model:

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{5}$$
$$\beta_{1j} = \gamma_{10} + u_{1j}$$
$$\beta_{2j} = \gamma_{20} + u_{2j}$$
$$\beta_{3j} = \gamma_{30} + u_{3j}$$

Combined Model:

$$(Y_{ij}|M_{2009}/M_{2012}) = \gamma_{00} + \gamma_{10} * (ENTUSE_{\mathrm{ij}}) + \gamma_{20} * (HOMSCH_{\mathrm{ij}}) + \gamma_{30} * (ICTHOME_{\mathrm{ij}}) + u_{0\mathrm{j}} + u_{1\mathrm{j}} * (ENTUSE_{\mathrm{ij}}) + u_{2\mathrm{j}} * (HOMSCH_{\mathrm{ij}}) + u_{3\mathrm{j}} * (ICTHOME_{\mathrm{ij}}) + r_{\mathrm{ij}} \tag{6}$$

In this model, β_{0j} stands for mean outcome variable, β_{1j}, β_{2j}, and β_{3j} stand for slope or the effects of predictors, r_{ij} coefficient stands for the random effect for i student clustered in j school, u_{0j} stands for error coefficients.

Model 3 is called Intercept and Slopes as Outcomes Model. This model was established in accordance with the third research question. The equation for this model is as Equation 7, Equation 8 and Equation 9.

Level - 1 (Student level) model:

$$(Y_{ij}|M_{2009}/M_{2012}) = \beta_{0j} + \beta_{1j} * (ENTUSE_{ij}) + \beta_{2j} * (HOMSCH_{ij}) + \beta_{3j} * (ICTHOME_{ij}) + r_{ij} \tag{7}$$

Level - 2 (School level) model:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} * (ICTSCH_{\mathrm{ij}}) + \gamma_{02} * (USESCH_{\mathrm{ij}}) + u_{0j} \tag{8}$$

Combined model:

$$(Y_{ij}|M_{2009}/M_{2012}) = \gamma_{00} + \gamma_{01} * (ICTSCH_{\mathrm{ij}}) + \gamma_{02} * (USESCH_{\mathrm{ij}}) + \gamma_{10} * (ENTUSE_{\mathrm{ij}}) + \gamma_{20} * (HOMSCH_{\mathrm{ij}}) + \gamma_{30} * (ICTHOME_{\mathrm{ij}}) + u_{0\mathrm{j}} + r_{\mathrm{ij}} \tag{9}$$

RESULTS

Within the scope of the aim of the study, the results were obtained from Random Effects Model of One-Way Variance Model developed based on PISA 2009 mathematics achievement and PISA 2012 mathematics achievement to answer the first research question are given in Table 2 (see Appendix).

When Table 2 is examined, it is seen that average school mean mathematics achievement of PISA 2009 was statistically different from zero (t = 73.36, p < .001). Considering the mean and variance, the mean mathematics achievement of PISA 2009 varied between 424.48 and 447.76 by a possibility of 95% (436.12 ± 1.96(5.94)). For PISA 2012 data set, average school mean mathematics achievement was statistically different from zero (t = 77.04, p < .001). In addition to that, the mean mathematics achievement of PISA 2012 shifted from 428.71 to 451.09 within 95% confidence interval. Table 3 is related to the information on the last estimation of the random effects in the model (see Appendix).

When Table 3 is reviewed, considering the general average in Turkey, the variance of school means (inter-school variability) was estimated to be 5795.96 for PISA 2009. The variance of the student's mathematics achievement scores was estimated to be 3502.58 within the framework of the school average (intra-school variability) at the student level (level 1). The value range for the school averages shifted from 286.9 to 585.33 by a possibility of 95% ($436.12 \pm 1.96*\sqrt{5795.96}$). The variance of school means (inter-school variability) was estimated to be 5327.39 for PISA 2012. The variance of the student's mathematics achievement scores was estimated to be 3158.00 within the framework of the school average at the student level for PISA 2012. With 95% confidence, the school averages range from 296.85 to 582.95.

These results showed that there is a broad range of variance in mathematics achievement levels between the schools. In order to determine the explained variance ratio of students' mathematics achievement scores in PISA 2009 and PISA 2012, the interclass correlation coefficient and the intraclass correlation coefficient were calculated, and the calculations are given in Table 4. The intraclass correlations are related to the difference between students, and the interclass correlations are regarding the difference between schools (see Appendix).

Table 4 presented that the difference between the mathematics achievement scores of the students was found to be 62% in both PISA 2009 and PISA 2012. The remaining 38% of the variability in mathematics achievement was within the schools. It refers that mean mathematics achievement of schools differs heterogeneously between schools. These coefficient values show that there is an explained variance between schools. Therefore, the analysis was continued, including variables at student and school levels. The student-level variables were added to reduce the variance within schools, and the school-level variables were added to explain between-school variance.

The second research question is related to the explained variance ratio at the student level ICT variables in students' mathematics achievement scores PISA 2009 and PISA 2012. In order to examine this research question, three variables which are the ICT availability at home (ICTHOME), the ICT use for entertainment (ENTUSE), the ICT use at home for school-related tasks (HOMSCH) were added in the model. This model includes in level-1 variables. The findings regarding Random Coefficients Regression Model are given in Table 5 (see Appendix).

Considering each of the predictor variables at student level, which affect mathematics achievement, other variables were held fixed except one to determine its impact in Table 5. The relationship between the ICT use for entertainment (ENTUSE) and PISA 2009 mathematics achievement was positive, and this relationship was statistically significant ($M_{ENTUSE\gamma 10} = 3.85$, $SE = 0.92$, $p < .05$). The ICT use at home for school-related tasks (HOMSCH) decreased PISA 2009 mathematics achievement, and this decline was statistically significant ($M_{HOMSCH\gamma 20} = -8.77$, $SE = 0.99$, $p < .05$). The relationship between the ICT availability (e.g. laptop, computer, printer, USB, internet connection) at home (ICTHOME) and PISA 2009 mathematics achievement was positive, and this relationship was statistically significant ($M_{ICTHOME\gamma 30} = 6.39$, $SE = 0.94$, $p < .05$). In order to compute the effect size of each student level variable which has a significant effect on mathematics achievement, each beta coefficient was divided by the pooled within-school standard deviation. The pooled within-school standard deviation is computed by taking the square root of σ^2 in Null Model (von Secker & Lissitz, 1999). Effect size is a standard deviation (SD) unit that allows comparison of outcomes with different measurements. It describes changes in the dependent variable when other independent variables are held fixed. Thus, it can be represented as the SD change in the dependent variable connected to 1SD change in an independent variable. If the value of effect size is computed as smaller than .1 SD, the effect is trivial. If the effect size value is between .1 SD and .3 SD, the effect is small. If the effect size value is between .3 SD and .5 SD, the effect is moderate. If the effect size value is computed as larger than .5 SD, this effect is large (Rosenthal & Rosnow, 2008; von Secker & Lissitz, 1999). When Table 3 was examined, the standard deviation was calculated as 59.2 ($\sqrt{3502.58}$) for within-school. The beta coefficient value for the ENTUSE variable was 3.85 in Table 5. The effect size value of the ENTUSE variable was calculated as .07 SD. It means that an increase of 1 SD in the variable of ENTUSE causes an increase of .07 SD in the students' mean mathematics achievement. The effect size value was calculated as .15 SD for the HOMSCH variable, and as .11 SD for the ICTHOME variable. The effect size of the HOMSCH variable indicates that an increase of 1 SD in the HOMESCH variable results in a decrease of .15 SD in the students' mean mathematics achievement. The effect size of the ICTHOME variable interprets as the .11 SD increase in the students' mean mathematics achievement linked to 1 SD increase in the ICTHOME variable. Considering the effect sizes, the HOMSCH and the ICTHOME variables had small effects, and the ENTUSE had a trivial effect on student's mathematics achievement in PISA 2009.

The ICT use for entertainment (ENTUSE) increased their PISA 2012 mathematics achievement, so this increment was statistically significant ($M_{ENTUSE\gamma 10} = 4.04$, $SE = 0.76$, $p < .05$). The relationship between the ICT use at home for school-related tasks (HOMSCH) and PISA 2012 mathematics achievement was negative, but this relationship was not statistically significant ($M_{HOMSCH\gamma 20}$ = -1.60, *SE* = 0.97, *p* > .05). The relationship between the ICT availability (e.g., laptop, computer, printer, USB, internet connection) at home (ICTHOME) and PISA 2012 mathematics achievement was also positive, and this relationship was statistically significant ($M_{ICTHOME\gamma 30}$ = 2.71, *SE* = 0.84, *p* < .05). When Table 3 was examined, the standard deviation was calculated as 56.1 ($\sqrt{3158.00}$). The value of effect size was calculated as .07 SD for the ENTUSE variable and as .05 SD for the ICTHOME variable. The effect size of the ENTUSE variable indicates that an increase of 1 SD in the ENTUSE variable results in an increase of .07 SD in the students' mean mathematics achievement. The effect size of the ICTHOME means that an increase of 1 SD in the variable of ICTHOME causes an increase of .05 SD in the students' mean mathematics achievement. When the effect size value of each variable was reviewed, each of the predictive variables had a trivial effect on students' mathematics achievement in PISA 2012.

The random effect of predictive variables which were caused by the variance between schools in students' PISA mathematics achievements is given in Table 6 (see Appendix).

When Table 6 is reviewed, the variance of the mathematics achievement scores of the schools was estimated to be 5807.83 in PISA 2009 and 5329.93 in PISA 2012, after the student level variables were added to the model. In order to determine the explained variance ratio in 2009 mathematics achievement caused by the difference within schools, the data obtained from the One-Way Variance Analysis and the data obtained in Table 6 were used. The explained variance ratio in PISA 2009 mathematics achievement at the student level is calculated as 0.027 [(3502.58 - 3405.48) / (3502.58)]. According to this result, there is a decrease of 2.7% in the explained variance ratio with the addition of the student level variables to the model in PISA 2009. In other words, the proportion of 2.7% of students' individual differences in PISA 2009 mathematics achievement results from the student level ICT variables added to the model (the ICT availability at home, the use of ICT for entertainment, the use of ICT at home for school-related task). Considering the Null model, 38% of the total variance in PISA 2009 mathematics achievement was caused by the differences between students. Thus, only 1.03% (38% * 2.7%) of the total variance of the student level ICT variables explained the difference of PISA 2009 mathematics achievement.

The variance ratio in PISA 2012 mathematics achievement explained by the student level ICT variables was calculated as 0.012. Accordingly, the explained variance ratio will decrease nearly by 1.2% after the student level variables are added to the model. In other words, the percent of 1.2 of the variability in students' PISA 2012 mathematics achievement is caused by the student level ICT variables added to the model (r^2 = .012). Considering the Null model, 38% of the total variance in PISA 2012 mathematics achievement was caused by the differences between students, only 0.45% (38% * 1.2%) of the total variance of the student level ICT variables explained the difference of PISA 2012 mathematics achievement.

Intercept and Slopes as Outcomes Model was tested to answer the third research question of the study. The model is obtained by the inclusion to the analysis all of the ICT variables which were determined to have a significant effect on the mathematics achievement at student and school level in PISA 2009 and PISA 2012. The findings regard the Intercept and Slopes as Outcomes Model are given in Table 7 (see Appendix).

In table 7, it is seen that PISA 2009 mean mathematics achievement and PISA 2012 mean mathematics achievement was statistically different from zero ($\gamma_{00} = 435.69$, *p* < .001 for PISA 2009; $\gamma_{00} = 438.30$, *p* < .001 for PISA 2012). When the variable of the ICT use at school (USESCH) was holding fixed, it was determined that the variable of the ICT availability at school (ICTSCH) had a significant effect on mathematics achievement in PISA 2009. When the variable of the ICT availability at school (ICTSCH) was holding fixed, the ICT use at school (USESCH) variable reduced PISA 2009 average mathematics achievement. Holding fixed the variables which are the ICT availability at home (ICTHOME) and the ICT use at home for school-related tasks (HOMSCH), the variable of the ICT use for entertainment (ENTUSE) increased PISA 2009 average mathematics achievement. When the variables of the ICT availability at home (ICTHOME) and the ICT use for entertainment (ENTUSE) were holding fixed, the variable of the ICT use at home for school-related tasks (HOMSCH) decreased PISA 2009 average mathematics achievement. Holding fixed the variables of the ICT use for entertainment (ENTUSE) and the ICT use at home for school-related tasks (HOMSCH), the ICT availability at home (ICTHOME) increased PISA 2009 average mathematics achievement. The variables with the highest impact value in PISA 2009 mathematics achievement are the ICTSCH and USESCH variables. These variables are the school level variables. It is expected that 1 SD increase in the ICTSCH variable will increase .69 SD in the students' mean mathematics achievement while 1 SD increase in the USESCH variable will decrease 1 SD in the students' mean mathematics achievement in PISA 2009. When the student level variables reviewed, their effect size were not greater than the school level variables.

When the variable of the ICT use at school (USESCH) was holding fixed, the variable of the ICT availability at school (ICTSCH) increased PISA 2012 average mathematics achievement. When the variable of the ICT availability at school (ICTSCH) was holding fixed, the ICT use at school (USESCH) decreased PISA 2012 average mathematics achievement. When the variables which are the ICT availability at home (ICTHOME) and the ICT use at home for school-related tasks (HOMSCH) were holding fixed, the ICT use for entertainment (ENTUSE) increased PISA 2012 average mathematics achievement. When the variables of the ICT availability at home (ICTHOME) and the ICT use for entertainment (ENTUSE) were holding fixed, the ICT use at home for school-related tasks (HOMSCH) reduced PISA 2012 average mathematics achievement. Holding fixed the variables which are the ICT use for entertainment (ENTUSE) and the ICT use at home for school-related tasks (HOMSCH), the variable of the ICT availability at home increased PISA 2012 average mathematics achievement. The variables with the highest impact value in PISA 2012 mathematics achievement is the ICTSCH and USESCH variables. It is expected that 1 SD increase in the ICTSCH variable will increase .83 SD in the students' mean mathematics achievement while 1 SD increase in the USESCH variable will decrease .78 SD in the students' mean mathematics achievement in PISA 2012. When the student level variables reviewed, their effect sizes were not greater than the school level variables.

When Table 7 was examined in general, it was seen that the ICT variables at school level caused an excessive amount of increase and decrease in average mathematics achievement defined as outcome variable. However, the student level ICT variables caused a low amount of increase and decrease in average mathematics achievement. Table 8 comprises the random effect of predictive variables caused by the variance among students and schools of mathematics achievement (see Appendix).

The data obtained from Table 8 and the data obtained from Random Coefficients Regression Analysis were used to calculate the explained variance ratio in 2009 mathematics achievement caused by the student and school levels. According to the calculation, 27% of the variance in the between-school difference in mean PISA 2009 mathematics achievement was explained by the school level variables. Also, χ^2 = 5599.33 was calculated, and p value was found to be statistically significant, so it can be said that there is still an unexplained variance between schools. The effect size value was calculated as .69 for the ICTSCH variable, and as -1 for the USESCH variable. The value of effect size was calculated as .06 for the ENTUSE variable, as -.14 for the HOMSCH variable, and as .08 for the ICTHOME variable. When the effect sizes were reviewed, it was seen that the ICTSCH and the USESCH variables had a large effect, the HOMSCH had a small effect, and the ENTUSE and the ICTHOME had a trivial effect on student's mathematics achievement in PISA 2009.

For PISA 2012 mathematics achievement the variance ratio was calculated as 31% [(5327.39 - 3656.48) / 5329.93]. The variables which are the ICT availability at school and the ICT use at school explained 31% of the variance in the between-school difference in mean PISA 2012 mathematics achievement. In addition, χ^2 = 5901.47 was calculated, and p value was found to be statistically significant, so it can be said that there is still an unexplained variance between schools. When Table 3 was examined, the standard deviation was calculated as 72.9 ($\sqrt{5327.39}$). The effect size of the ICTSCH variable was calculated as .83. The effect size was calculated as -.78 for the USESCH variable. The effect size was calculated as .07 for the ENTUSE variable, and as .05 for the ICTHOME variable. When the effect sizes were examined, it was seen that the ICTSCH and the USESCH variables had a large effect, the ENTUSE and the ICTHOME had a trivial effect on student's mathematics achievement in PISA 2012.

Four different models were established for HLM analyses in the study. Likelihood ratio test was calculated to determine whether the established the model 4 was better likelihood than the other models or not. For this reason, firstly, the difference of deviance statistics values of each model divides by the degree of freedom. The obtained value is compared to the critical chi-square value. The model is statistically significant if this value is greater than the critical value (critical $\chi^2 = 5.99$ for $p = .05$). The results of the likelihood ratio test using deviance statistics in each outcome variable to determine whether the Model 4 fits significantly better are given in Table 9 (see Appendix). When the results of the Likelihood ratio test for both PISA 2009 mathematics achievement and PISA 2012 mathematics achievement were examined, it could be said that the Model 4 fits significantly better.

DISCUSSION and CONCLUSION

In the study, the ICT variables predicting mathematics achievement at the student level and the school level were examined. When the student level ICT variables are reviewed, one of the variables at the student level is the ICT use for entertainment. There are studies in the literature similar to the consequence of this study in which there is a positive and significant relationship between the ICT use for entertainment and PISA mathematics achievement (e.g., Bilican-Demir & Yıldırım, 2016; Demir, Kılıç, & Ünal, 2010; Dumais, 2009; Hu, Gong, Lai, & Leung, 2018; Petko et al., 2017; Skryabin et al., 2015). It is emphasized that the usage of computers for entertainment such as playing games on computer which is thought by parents as a waste of time is important in the cognitive development of students (Becker, 2000; Hamlen, 2011; Li & Atkins, 2004) and in visual intelligence development (Subrahmanyam, Greenfield, Kraut, & Gross, 2001), which can positively affect achievement. Also, entertainment can help overcoming their stress and anxiety and thus, it can enable them to focus on their learning; besides, it can contribute to students' effective and critical thinking (Wittwer & Senkbeil, 2008; Ziya, Doğan, & Kelecioğlu, 2010). However, there are also studies about that the internet usage for entertainment is a negative and significant predictor of mathematics achievement in the literature (e.g., Cheema & Hang, 2013; Güzeller & Akın, 2014). The reason for this result can be explained by the fact that excessive ICT use for entertainment neglects students' responsibilities for school (Cheema & Hang, 2013; Luu & Freeman, 2011). If students' usage of ICT is not controlled and monitored, it will cause negative social and psychological effects such as addiction to game playing (Grüsser, Thalemann, & Griffiths, 2006). Moreover, the reason why there are inconsistent results related to the effect of ICT use for entertainment on mathematics achievement in the literature can be explained by the fact that the ICT use for entertainment causes different effects on different mathematics topics (Biagi & Loi, 2013). Further studies about the influences of the ICT activities for entertainment on students' academic outcomes and the causes of these influences are still needed.

Another variable dealt with at the student level is the ICT use at home for school-related tasks. In the study, it was found that the relationship between the ICT use at home for school-related tasks and PISA 2009 mathematics achievement is negative and significant. However, that relationship of it with PISA 2012 mathematics achievement is negative but not significant. There are studies with similar results in the literature (e.g., Hu et al., 2018). However, there are several studies that the use of ICT has a positive effect on learning outcome (e.g., Kubiatko & Vlckova, 2010; O'Neil, Wainess, & Baker, 2005; Skryabin et al., 2015). The students' ICT use for school-related tasks mostly includes homework. Turkish students frequently have difficulty in mathematics homework (Güven & Demirçelik, 2013; MEB, 2011). Thus, students may develop negative prejudices and attitudes towards mathematics lessons and homework (Yenilmez & Dereli, 2009). This case can negatively affect achievement. Besides, the students' spending much time on ICT activities not related to their school-related tasks (Zhang & Liu, 2016) and their lack of knowledge how to use ICT for accomplishing school-related tasks (Kubiatko & Vlckova, 2010; Petko et al., 2017) are among the factors that affect achievement negatively.

The other variable dealt with at the student level is about the ICT availability at home (ICTHOME), and it was concluded that the relationship between this variable and PISA mathematics achievement in 2009 and 2012 is positive and significant in this study. This result is consistent with the results of some studies in the literature (e.g., Delen & Bulut, 2011; Demir & Kılıç, 2009; Erdoğdu & Erdoğdu, 2015; Özer & Anıl, 2011). Taking into consideration to this result, it can be mentioned that the students can reach more information from several sources regarding the topics (Kubiatko & Vlckova, 2010). Also, the average percentage of internet access at home has increased over the years (OECD.Stat, 2018). Yet, Aypay (2010), Bilican-Demir and Yıldırım (2016), and Wittwer and Senkbeil (2008) couldn't find a significant relationship between the student's ICT opportunity and achievement in their studies. Hu et al. (2018) found that ICT availability at home is negatively associated with student's academic success. The reason for this inconsistency in literature can be explained by the fact that while the ICT availability at home gives many opportunities in education, the ineffective usage of ICT for education can affect his/her education negatively (Hu et al., 2018; Lei & Zhao, 2007). In brief, achievement is affected by how and for what purpose the availability of ICT is used at home (İlgün-Dibek, Yalçın, & Yavuz, 2016).

One of the variables dealt with at school level in the study is the ICT availability at school (ICTSCH), and a positive and significant relationship was found between this variable and PISA mathematics achievement in 2009 and 2012. In literature, there are studies having reached similar results (Delen & Bulut, 2011; Hu et al., 2018; Olkun & Altun, 2003; Özer & Anıl, 2011). The students in schools with ICT facilities can have access to more information using several sources regarding lessons (Kubiatko & Vlckova, 2010). The schools in Turkey are also well enough with regard to ICT devices (Seferoğlu, 2015). Another variable at school level is ICT use at school (USESCH). And, the consequence of its negative and significant relationship with PISA mathematics achievement in 2009 and 2012. Bilican-Demir and Yıldırım (2016), Cheema and Hang (2013) and Petko et al. (2017) found similar findings using PISA data and Skryabin et al. (2015) reached similar results using TIMMS dataset. This may be due to the lack of restrictions on access to websites in schools (Kubiatko & Vlckova, 2010). Another reason can be the students' unfamiliarity with ICT use in lessons (İlgün-Dibek et al., 2016). One of the other reasons is that the teacher's proficiency in ICT and their information in teaching methods can be lacking and insufficient (Baki, Yalçınkaya, Özpınar, & Uzun, 2009; Pandolfini, 2016). Because, if the students' learning targets with ICT are not certain, the teaching value of ICT is low (Kubiatko & Vlckova, 2010), and it gets harder to reach the targeted achievement. The applicability of the FATİH project in Turkey is discussed in this context, because the number of teachers using the ICT in lessons is very low, and they generally use word processor and presentation programs actively (Demiraslan & Usluel, 2005; Kayaduman, Sırakaya, & Seferoğlu, 2011).

In the study, it is noticed that the results regarding the relationship between ICT variables at student level and school level and PISA mathematics achievement are consistent with the results of some studies but contradict with some other studies in the literature. One of the reasons for this can be methodological restrictions and differences (Cox & Marshall, 2007; De Witte & Rogge, 2014). The different data analysis techniques were used in studies with PISA dataset or one of the other large-scale assessments. Also, the results of this study were compared with the results of studies using PISA dataset of the different countries in literature, and some of the results were determined to be consistent and some others to be inconsistent with them. This case could be caused by the fact that each country has its own educational policies and applications regarding ICT use, and these ICT applications and these ICT skills may be different in each country (Heinz, 2016; Skryabin et al., 2015).

The variables dealt with both at student level and at school level in the study can be categorized as ICT availability and ICT use. At both levels, it was concluded that ICT availability increases achievement, but ICT use is not effective in increasing achievement. Thus, the technological richness of a house or a school does not mean that using these technologies effectively. Effective technology usage is connected to the knowledge, the ability, and the experiences of the parents at homes and of the administrators and the teachers at schools (Hu et al., 2018; Lei & Zhao, 2007; Seferoğlu, 2015).

One of the other results of this study is that the explained variance ratio in mathematics achievement caused by the ICT variables at school level was greater than by the ICT variables at student level. This situation can be affected by the factors such as the principals' awareness of the ICT applications, the school culture, the cooperation regarding how ICT is used in schools, the teachers' ICT proficiency, the teacher education on teaching methods (Pandolfini, 2016) and the pedagogical developments (Ertmer & Ottenbreit-Leftwich, 2010).

This study also examined the comparison of mathematics achievement between PISA 2009 and PISA 2012. Mathematics is the major domain in PISA 2012, but this domain was minor in PISA 2009. Therefore, the effect of ICT on mathematics achievement was compared with whether it depends on the focused domain. Comparing the results regarding mathematics achievement of PISA 2009 and PISA 2012, it was concluded that whether the major domain is mathematics, in other words, mathematics achievement test is long or short did not make a serious difference in mathematics achievement.

When the effect sizes of the student level variables on mathematics achievement were compared with two implementations of PISA which are PISA 2009 and PSA 2012, the ENTUSE had a trivial effect on student's mathematics achievement in both PISA 2009 and PISA 2012. While the relationship between the HOMSCH variable and PISA 2009 mathematics achievement was negative and statistically significant, the relationship between the HOMSCH variable and PISA 2012 mathematics achievement was negative and not statistically significant. The ICTHOME variable had a small effect on PISA 2009 mathematics achievement, but this variable had a trivial effect on PISA 2012 mathematics achievement. The effect size value of ICTHOME variable on mathematics achievement in the PISA 2012 implementation was lower than in the PISA 2009 implementation. The reason of the trivial and the small effect of student level variables may be the students' competence and awareness of the effective ICT use (Grüsser et al., 2006) and the parents' views of the ICT use (Becker, 2000; Hamlen, 2011; Li & Atkins, 2004).

When the effect sizes of the school level variables on mathematics achievement were compared with two implementations of PISA which are PISA 2009 and PSA 2012, The ICTSCH variable and the USESCH variable at the school level had a large effect on mathematics achievement in both PISA 2009 and PISA 2012. The reason for the large effect of the ICTSCH variable at the school level can be explained by the perspective that a good learning environment has an effect on the students' achievement (Youssef & Dahmani, 2008). The ICTSCH variable had a positive effect on mathematics achievement in both PISA 2009 and PISA 2012. The effect size value of the ICTSCH variable on mathematics achievement in the PISA 2012 implementation was higher than in the PISA 2009 implementation. The relationship between the USESCH variable and mathematics achievement in PISA 2009 and PISA 2012 was negative and statistically significant. The result of the negative relationship may be due to the teachers' quality and characteristics of the usage of ICT (Youssef & Dahmani, 2008). The effect size value of USESCH variable on mathematics achievement in the PISA 2012 implementation was lower than in the PISA 2009 implementation. The effect size value of the USESCH variable reduced in PISA 2012, but there has been a negative relationship between the USESCH variable and mathematics achievement. The reason for this negative relationship may be related to many barriers such as lack of confidence and competence and access to resources encountered (Bingimlas, 2009). In other words, the school principals' and the teachers' perceptions and their usage of ICT have not changed seriously over the years. In brief, the higher impact variables on mathematics achievement in both PISA 2009 and PISA 2012 were the ICTSCH variable and the USESCH variable which are the school level variables. The student level variables had the lowest impact on mathematics achievement in both PISA 2009 and PISA 2012.

It was found that the ICT variables both at school level and at student levels explained 27% of PISA 2009 mathematics achievement variance, while these variables explained 31% of PISA 2012 mathematics achievement variance. So, it was noticed that there was a slight increase in the explained variance ratio from 2009 to 2012. Yet the explained variance ratio at student level was calculated as 2.7% in PISA 2009, and this ratio was accounted for 1.2% for PISA 2012. When the student level variables were compared by years, the effect of the ICT variables at student level had reduced from 2009 to 2012. The reason of the small amount of variance increase obtained from the study can be explained by the slight increase of the ICT use awareness of the families, the teachers, and the administrators who shape the students' ICT use at home or at school. If students have several ICT availabilities, these opportunities offer a great number of sources and access to information for students' learning. However, it should be remembered that the usage and the purpose of ICT affect the students' learning (İlgün-Dibek et al., 2016).

Having a negative relationship between ICT use at home for school-related tasks and mathematics achievement actually poses a problem. This problem can be solved by changing the content of the school-related tasks. For instance, the school-related mathematical tasks may include entertaining components that help students to develop a love for mathematics. Besides, students can be consciously directed to use online materials for school-related tasks and for accomplishing their homework. Also, there are important responsibilities at home for families. One of them is the families' monitoring. Another responsibility is controlling the students' ICT use materials at home and teaching their children how to use online materials consciously.

The negative relationship between ICT use at school and mathematics achievement is another problem. In order to eliminate this problem, ICT use for entertainment can be integrated into lessons. For instance, games can be utilized to be successful in mathematics lessons at schools. For effective ICT applications, the teachers' ICT proficiency is important. Therefore, the teachers should be encouraged to participate in in-service training for developing their ICT proficiencies. Besides, there is a need for projects related to increasing the teachers' effective ICT use and the families' awareness of ICT use. Students' socio-economic background, age and gender, and learning expectations are important factors that affect ICT use and achievement (Balanskat, Bannister, Hertz, Sigillò, & Vuorikari, 2013). However, these variables were not included in the model in this study. This is one of the limitations of this study. As a suggestion to this limitation, some researches in which the variables related to the student's characteristics, the learning environment, and the school features are added in the model can be done. The other limitation of this study is to use two level Hierarchical Linear Modelling. Several studies can be offered for different multi-levels (e.g., three level models) related to investigating the effect of ICT on achievement by adding these variables into the model. The data in this study is limited to only one country. The studies related to comparing the effect of ICT usage on achievement between different countries are suggested to be performed.

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Bilgi ve İletişim Teknolojilerine Erişim Düzeyi ve Kullanımı PISA 2009 ve 2012 Öğrenci Başarısını Nasıl Etkiler?

Giriş

Matematik öğretme ve öğrenme sürecinde bilgisayarların kullanımının önemi yıldan yıla artış göstermekte ve bilgi ve iletişim teknolojilerinin (BİT) matematik başarısını olumlu yönde etkileyeceği düşüncesi ile BİT'e ilişkin ciddi miktarlarda yatırımlar yapılmaktadır (Anderson, 2008; Kim, Kil, & Shin, 2014; Scheuermann & Pedró, 2009). Yapılan yatırımların ve sonuçların hem ulusal hem de uluslararası boyutta PISA (Uluslararası Eğitim Değerlendirme Testi) ve TIMMS (Uluslararası Matematik ve Fen Eğilimleri Araştırması) gibi uygulamalar ile değerlendirilmesine ve BİT ile akademik başarı arasındaki ilişkiye yönelik çalışmalar hız kazanmaya başlamıştır (OECD, 2014b; Skryabin, Zhang, Liu, & Zhang, 2015; Şengül & Demir, 2018). BİT'e dayalı öğretim ve öğrenme ile başarı arasındaki ilişkiyi belirlemek amacıyla yapılan çalışmalardan kesin bir sonucun elde edilemediği ve bu çalışmaların sonuçlarının birbiri ile tutarsız olduğu görülmüştür (Balanskat, Blamire, & Kefala, 2006; Cox & Marshall, 2007; De Witte & Rogge, 2014; Skryabin ve diğerleri, 2015; Trucano, 2005). Ayrıca bu tür araştırmalar, genellikle bireysel ve basit düzeydedir. BİT'in başarıyı nasıl etkilediğine ve başarıda hangi BİT değişkenlerinin rol oynadığına yönelik çok düzeyli yaklaşımların yer aldığı çalışmalar ise oldukça azdır (Pandolfini, 2016). Ek olarak, bu tür çalışmalarda genellikle PISA uygulamasının tek yılına odaklanılmıştır (örneğin, Demir & Kılıç, 2009; Güzeller & Akın, 2014; Petko, Cantieni & Prasse, 2017). BİT değişkenlerinin öğrencinin matematik başarısını açıklama düzeyini farklı yıllarda uygulanan PISA verilerine göre karşılaştıran bir çalışmaya rastlanılmamıştır. Bunun bir nedeni PISA'da farklı yıllarda odaklanılan alanın değişmesi olabilir ancak az soruyla da olsa tüm alanların her yıl ölçüldüğü de bir gerçektir. Bu çalışmada da PISA 2009 ve 2012 uygulamalarında öğrencilerin matematik başarılarının bilgi ve iletişim teknolojilerine erişim ve kullanım düzeyleri açısından değerlendirilmesi amaçlanmaktadır. Her PISA uygulamasında okuma, fen ve matematik okuryazarlığından birine odaklanılmaktadır. PISA 2012 uygulamasında matematik okuryazarlığına odaklanılırken, PISA 2009'da okuma okuryazarlığa odaklanılmıştır. Böylece odaklanılan alana bağlı olarak, BİT değişkenlerinin matematik başarısını açıklama oranı belirlenebilecektir. Bu bağlamda, bu çalışma ile PISA 2009 ve 2012 sonuçlarına göre, Türkiye'deki öğrencilerin bilgi ve iletişim teknolojilerine erişim ve kullanım düzeylerinin matematik başarısını açıklama oranının belirlenmesi amaçlanmaktadır. Çalışmanın amacı doğrultusunda araştırma soruları ise şunlardır:

1. PISA 2009 ve 2012 Türkiye verisine göre, matematik başarısındaki değişkenliğin okullar arasındaki farklılıklar ve öğrenciler arasındaki farklılıklar tarafından açıklanma oranı nedir?
2. PISA 2009 ve 2012 Türkiye verisine göre, matematik başarısındaki değişkenliğin öğrenci düzeyinde ele alınan bilgi ve iletişim teknolojilerine erişim ve kullanımı ile ilgili değişkenler tarafından açıklanma oranı nedir?
3. PISA 2009 ve 2012 Türkiye verisine göre, matematik başarısındaki değişkenliğin okul düzeyinde ele alınan bilgi ve iletişim teknolojilerine erişim ve kullanımı ile ilgili değişkenler tarafından açıklanma oranı nedir?
4. PISA 2009 ve 2012 Türkiye verisine göre, matematik başarısındaki değişkenliğin hem öğrenci düzeyindeki hem de okul düzeyindeki BİT'e ilişkin değişkenler tarafından açıklanma oranı nedir?

Bu çalışmanın, alan yazına çeşitli açılardan katkı sağlayacağı düşünülmektedir. Bu katkılar: (a) BİT'in erişim ve kullanım düzeyinin matematik başarısı üzerindeki etkisinin açıklığa kavuşabilmesidir. (b) Alan yazında, BİT değişkenlerinin matematik başarısındaki varyans açıklama oranının farklı yıllar açısından karşılaştıran çalışmaların eksik olduğu görülmektedir. Bu çalışmada öğrencilerin matematik başarısında açıklanan varyans oranının belirlenmesinde etkili olan BİT değişkenleri farklı yıllar açısından araştırılmıştır. Açıklanan varyans oranı, BİT'in matematik eğitiminde etkili kullanımına dair bir fikir verilebilir. (c) Bu araştırmada hiyerarşik doğrusal modeller oluşturulmuştur. PISA verisinin yapısı dikkate alındığında, hiyerarşik modellerin tahmini standart hatayı daha iyi kalibre ettiği için, daha doğru sonuçlara ulaşmak ve bulguları daha az hatayla yorumlamak açısından önemli olduğu söylenebilir. (d) PISA 2012 matematik alanına odaklanırken, PISA 2009 okuma alanına odaklanmıştır. Bu çalışma, BİT değişkenlerinin matematik başarısı üzerindeki etkisinin alana bağlı olarak değişip değişmediğini yorumlama fırsatı da sağlayacaktır. Bu nedenle, bu çalışmanın BİT'in matematik başarısı üzerindeki etkisine ilişkin bütüncül bir bakış açısı sunması bağlamında önemli olduğu düşünülmektedir.

Yöntem

Bu araştırmada ilişkisel araştırma modeli kullanılmıştır. Araştırmanın PISA 2009 uygulamasının örneklemi 56 il ve okul türlerine göre tabakalandırılması sonucu toplam 170 okuldan 4996 öğrenciden, PISA 2012 uygulamasının örneklemi ise 57 il ve okul türlerine göre tabakalandırılması sonucu 170 okuldan toplam 4848 öğrenciden oluşmaktadır. Araştırmada Türkiye'de uygulanan PISA 2009 ve PISA 2012 matematik başarı testinden ve her iki uygulamada öğrencilerin bilgi ve iletişim teknolojilerine yatkınlık (BİTY) anketindeki ortak indekslerden elde edilen veriler kullanılmıştır. BİTY anketindeki BİT'in evde bulunması (ICTHOME), BİT'in eğlence amaçlı kullanımı (ENTUSE) ve BİT'in okul görevlerini yerine getirmek için evde kullanımı (HOMSCH), BİT'in okulda bulunması (ICTSCH), BİT'in okulda kullanılması (USESCH) indeksleri hem PISA 2009 hem de PISA 2012 uygulamasında yer alan ortak BİTY indeksleridir.

Araştırmada kullanılan PISA verilerinin hiyerarşik bir yapısı olduğu için veri analizinde iki düzeyli Hiyerarşik Lineer Modelleme (HLM) analizi kullanılmıştır. Modelin birinci düzeyinde öğrenci, ikinci düzeyinde okul değişkenleri ele alınmıştır. Ele alınan PISA verilerinin HLM analizi için varsayımları incelendiğinde, veri setindeki kayıp veri oranı düşük olduğu için kayıp verilerin atanmasında HLM programındaki kayıp veri yöntemlerinden faydalanılmıştır. Örneklem büyüklüğü dikkate alındığında, uç değerlerin atılmasına yönelik herhangi bir işlem yapılmamıştır. HLM'nin varsayımlarından çoklu bağlantı sorununun olup olmadığının belirlenmesine ilişkin birinci düzeyde (öğrenci) ve ikinci düzeyde (okul) yer alan bağımsız değişkenler arasındaki korelasyon katsayı değerleri hesaplanmıştır ve bu değerlerin 0.70'in altında olduğu saptanmıştır. Araştırmada birinci düzey değişkenleri grup ortalaması etrafında merkezileştirilirken; ikinci düzey değişkenleri genel ortalama etrafında merkezileştirilmiştir. HLM'in diğer bir varsayımında öğrenci düzeyindeki hataların ve okul düzeyindeki hataların dağılımının normalliği incelenmiştir. Bunun için histogram ve olasılık grafikleri (P-P plot veya Q-Q plot) elde edilmiştir ve bu grafiklerin 45 derecelik bir doğru oluşturduğu gözlemlenmiştir. Dolayısıyla her iki düzeydeki hataların normallik sayıltısı sağlanmıştır. Öğrenci düzeyi varyansların homojenliği için H istatistiği hesaplanmış ve p değeri manidar bulunmuştur. Bağımsızlık sayıltısı incelendiğinde de PISA 2009 matematik değişkeninde ve PISA 2012 matematik değişkeninde okul-içi hataların öğrenci düzeyindeki değişkenlerden bağımsız olduğu bulunmuştur.

Araştırmanın amacı doğrultusunda üç model kurulmuştur. Bu modeller sırasıyla tek yönlü varyans analizi rastgele etkiler modeli (boş model ya da yokluk modeli olarak da adlandırılmaktadır), rastgele katsayılar regresyon modeli ve kesişim ve eğim katsayılarının bağlı olduğu modeldir. Tek yönlü varyans analizi rastgele etkiler modeline birinci düzeye ve ikinci düzeye ait herhangi bir değişken eklenmemiştir ve birleştirilmiş model Eşitlik 1'de verilmiştir.

$$(Y_{ij}|/M_{2009}/M_{2012}) = \gamma_{00} + u_{0j} + r_{ij} \tag{1}$$

Rastgele katsayılar regresyon modeline öğrenci düzeyindeki matematik başarısında BİT değişkenlerinden kaynaklanan kısmını açıklamak için BİT'e evde ulaşabilirlik (ICTHOME), BİT'in eğlence amaçlı kullanılması (ENTUSE), BİT'in okul görevlerini yerine getirmek için kullanımı (HOMSCH) olmak üzere toplam üç değişken eklenmiştir ancak ikinci düzeye ait herhangi bir değişken eklenmemiştir ve birleştirilmiş model Eşitlik 2'de verilmiştir.

$$\begin{aligned}(Y_{ij}|M_{2009}/M_{2012}) \ &= \gamma_{00} + \gamma_{10} * (ENTUSE_{\mathrm{ij}}) + \gamma_{20} * (HOMSCH_{\mathrm{ij}}) + \gamma_{30} * (ICTHOME_{\mathrm{ij}}) + \\ &u_{0\mathrm{j}} + u_{1\mathrm{j}} * (ENTUSE_{\mathrm{ij}}) + u_{2\mathrm{j}} * (HOMSCH_{\mathrm{ij}}) + u_{3\mathrm{j}} * (ICTHOME_{\mathrm{ij}}) + r_{\mathrm{ij}}\end{aligned} \tag{2}$$

Kesişim ve eğim katsayılarının bağlı olduğu model, Türkiye'de öğrencilerin PISA 2009 matematik ve 2012 matematik başarısı ile ilişkili olan BİT'e yönelik öğrenci özelliklerinin, okulun BİT'e yönelik hangi özellikleri ile ilişkili olduğunu belirlemeye yöneliktir. Bu modele öğrenci düzeyindeki üç değişken ve okul düzeyindeki iki değişken eklenmiştir ve birleştirilmiş model Eşitlik 3'te verilmiştir.

$$\begin{aligned}(Y_{ij}|M_{2009}/M_{2012}) \ &= \gamma_{00} + \gamma_{01} * (ICTSCH_{\mathrm{ij}}) + \gamma_{02} * (USESCH_{\mathrm{ij}}) + \gamma_{10} * (ENTUSE_{\mathrm{ij}}) + \gamma_{20} * \\ &(HOMSCH_{\mathrm{ij}}) + \gamma_{30} * (ICTHOME_{\mathrm{ij}}) + u_{0\mathrm{j}} + r_{\mathrm{ij}}\end{aligned} \tag{3}$$

Sonuç ve Tartışma

Araştırmada öğrenci düzeyinde ele alınan değişkenlerden BİT'in eğlence amaçlı kullanımı ile PISA matematik başarısı arasında pozitif ve manidar bir ilişkinin olduğu saptanmıştır. Bilgisayarda oyun oynama gibi bilgisayarın eğlence amaçlı aktiviteler için kullanımı aileler tarafından zaman kaybı olduğu düşünülse de bu tür aktivitelerin aslında öğrencilerin bilişsel gelişiminde (Becker, 2000; Hamlen, 2011; Li & Atkins, 2004) ve görsel zekayı geliştirmede (Subrahmanyam, Greenfield, Kraut, & Gross, 2000) önemli olduğunu unutmamak gerekir ve bu durum başarıyı olumlu yönde de etkileyebilir. Öğrencinin okul görevlerini yerine getirmek amaçlı BİT kullanımı ile PISA 2009 matematik başarısı arasındaki ilişkinin negatif ve manidar olması sonucu, okul görevlerini yerine getirmek amaçlı BİT kullanımının daha çok ödev içermesi ve öğrencilerin de genelde matematik ödevlerinde zorlanmaları (Güven & Demirçelik, 2013; MEB, 2011) ve bu durumun hem matematik dersine hem de ödevlere karşı olumsuz tutumlar oluşturması ile açıklanabilir (Yenilmez & Dereli 2009). Öğrencinin evde ve okulda BİT'e dayalı materyallere sahip olması ile PISA matematik başarısı arasındaki ilişkinin pozitif ve manidar olduğu sonucu, öğrencinin konu ile ilgili çeşitli kaynaklardan daha fazla bilgiye erişebilmeleri ile açıklanabilir (Kubiatko & Vlckova, 2010). Okulda BİT'in kullanımı ile PISA matematik başarısı arasında negatif ve manidar bir ilişkinin olması, okulların eğitim ile ilgili olan web sayfalarına erişimine izin vermemesi (Kubiatko & Vlckova, 2010), öğrencilerin derslerde BİT kullanımına aşina olmamaları (İlgün-Dibek, Yalçın, & Yavuz, 2016) ya da öğretmenlerin BİT yeterlikleri ve öğretim yöntemlerine ilişkin bilgilerinin eksik ya da yetersiz olması ile açıklanabilir (Baki, Yalçınkaya, Özpınar, & Uzun, 2009; Pandolfini, 2016).

Araştırmada hem öğrenci düzeyinde hem de okul düzeyinde ele alınan değişkenler BİT olanaklarına sahip olma ve bunların kullanımı şeklinde gruplandırıldığında, her iki düzeyde de BİT olanaklarına sahip olmanın başarıyı arttırdığı ancak BİT kullanımının başarıyı artırmada etkili olmadığı sonucuna ulaşılmıştır. Ayrıca araştırmada öğrenci düzeyinde ve okul düzeyindeki BİT değişkenleri ile PISA matematik başarısı arasındaki ilişkiye yönelik elde edilen sonuçların, alanyazındaki bazı çalışmalarla tutarlılık gösterirken, bazıları ile tutarlılık göstermediği görülmüştür. Bunun nedenleri metodolojik sınırlamalar (Cox & Marshall, 2007; De Witte & Rogge, 2014) ya da her ülkenin kendine özgü BİT kullanımına ilişkin eğitim politikalarının ve uygulamalarının olması ile açıklanabilir (Heinz, 2016; Skryabin ve diğerleri, 2015).

Öğrenci düzeyindeki ve okul düzeyindeki BİT değişkenlerinin başarıyı açıklama oranları karşılaştırıldığında, okul düzeyindeki BİT değişkenlerinin başarıyı açıklama oranının, öğrenci düzeyindeki BİT değişkenlerine göre daha fazla olduğu bulunmuştur. Bu bulgu, okul seviyesindeki müdürlerin BİT uygulamalarındaki farkındalıkları, okul kültürü, BİT'in okullarda nasıl kullanıldığı ile ilgili işbirliği, öğretmenlerin BİT yeterlikleri ve öğretim yöntemlerine ilişkin öğretmen eğitimi gibi faktörlerden kaynaklanabilir (Ertmer & Ottenbreit-Leftwich, 2010; Pandolfini, 2016).

Matematik okuryazarlığına PISA 2012'de odaklanırken, PISA 2009'da odaklanılmamıştır. BİT'in matematik başarısı üzerindeki etkisi, matematik alanına odaklanıldığı ve odaklanılmadığı yıllar açısından karşılaştırıldığında, öğrenci düzeyindeki BİT değişkenleri ile PISA matematik başarısı arasındaki ilişkinin değişmediği belirlenmiştir. Sadece öğrencinin okul görevlerini yerine getirmek amaçlı BİT kullanımı ile PISA 2009 matematik başarısı arasındaki ilişki manidarken, PISA 2012 için bu ilişki manidar bulunmamıştır. Okul düzeyindeki BİT değişkenlerinden USESCH değişkeni ile PISA 2009 ve PISA 2012 matematik başarısı arasındaki ilişki ayrı ayrı incelendiğinde de bu ilişkinin değişmediği saptanmıştır. Bu olumsuz ilişkilerin yıllara göre değişmemesinin nedeni, öğretmenlerin ya da okul yöneticilerinin güven ve yeterlilik eksikliği ve kaynaklara erişim ile ilgili karşılaşılan çeşitli engellerle ilgili olabilir. Hem öğrenci düzeyindeki hem de okul düzeyindeki değişkenlerin PISA 2009 matematik başarısı için etki büyüklükleri incelendiğinde, okul değişkenlerinden ICTSCH ve USESCH değişkenlerinin büyük etkiye, öğrenci düzeyi değişkenlerinden HOMSCH değişkeninin küçük etkiye ve ICTHOME ve ENTUSE değişkenlerinin ise önemsiz bir etkiye sahip olduğu bulunmuştur. PISA 2012 için okul düzeyi değişkenlerinin matematik başarısı üzerindeki etkisinin büyük olduğu, öğrenci düzeyi değişkenlerinin ise matematik başarısı üzerindeki etkisinin önemsiz olduğu saptanmıştır. Öğrenci düzeyindeki değişkenlerin başarı üzerindeki etkisinin önemsiz ve küçük olmasının nedeni, öğrencilerin BIT'in etkin kullanımındaki yetkinliği ve farkındalığı (Grüsser, Thalemann, & Griffiths, 2006) ve ebeveynlerin BİT kullanımına ilişkin görüşleri ile ilgili olabilir (Becker, 2000; Hamlen, 2011; Li & Atkins, 2004). ICTSCH değişkeninin okul düzeyinde etkisinin büyük olmasının nedeni, iyi bir öğrenme ortamının öğrencilerin başarısını olumlu etkilediği bakış açısı ile açıklanabilir (Youssef & Dahmani, 2008). USECH değişkeninin öğrencinin matematik başarısı üzerindeki etkisinin büyük olmasının nedeni de öğretmenlerin BİT'in kullanımıyla ilgili yeterliklerinden ve niteliklerinden kaynaklanabilir (Youssef & Dahmani, 2008). PISA 2009 ve PISA 2012 matematik başarısına ilişkin sonuçların karşılaştırılmasında, sınavın matematik odaklı olup olmamasının, başka bir ifade ile matematik başarı testinin uzun ya da kısa olmasının, ciddi bir fark oluşturmadığı da söylenebilir. Hem öğrenci hem de okul düzeyindeki BİT değişkenlerinin, PISA 2009 matematik başarısındaki değişkenliği açıklama oranı %27 iken, PISA 2012 matematik başarısındaki değişkenliği açıklama oranı %31 olarak bulunmuştur. Açıklama varyansındaki artışın az miktarda olduğu görülmektedir. Az miktardaki varyans artışının nedeni ise, öğrencinin evde ve okulda BİT kullanımını şekillendiren ailelerin, öğretmenlerin ve yöneticilerin BİT'in kullanımına ilişkin farkındalıklarının az da olsa artması ile açıklanabilir.

Araştırma sonuçlarından öğrencilerin okul görevlerini yerine getirmek amacıyla evde BİT'i kullanmaları ile matematik başarısı arasında negatif bir ilişkinin olması, bir sorun olarak karşımıza çıkmaktadır. Bu sorunun çözümü için öğretmenler, öğrencilere matematiği sevmelerine yardımcı olabilecekleri ve eğlence içerikli öğelerin matematik ödevlerinde kullanabilmelerini sağlayacak şekilde ödevlerin içeriği değiştirilebilirler. Ayrıca öğrenciler de ödevlerini yaparken çevrimiçi materyalleri okul görevlerinde kullanımı açısından yönlendirilmelerine gerek duyulmaktadır. Bu durumda hem öğretmenlere hem de evde ailelere önemli sorumluluklar düşmektedir. Evde ailelerin, çocuklarını BİT kullanma şekilleri açısından izlemeleri ve çocuklarını çevrim içi kaynak kullanımı konusunda bilinçlendirmeleri gerekmektedir.

Okulda BİT'in kullanımı ile matematik başarısı arasındaki negatif ilişki, diğer bir sorundur. Bu sorunu giderebilmek için, eğlence amaçlı BİT kullanımı derslere dahil edilebilir. Okulda matematik dersinde başarıyı artırmaya yönelik oyunlar seçilebilir. Ayrıca öğretmenlerin BİT'e ilişkin yeterliliklerini geliştirmeleri de önem kazanmaktadır. Dolayısıyla öğretmenlerin BİT'e ilişkin yeterliklerini geliştirmeleri için hizmet içi eğitimlere katılmaları teşvik edilmelidir. Ayrıca öğretmenlerin ders ortamında BİT'i etkili kullanmaya ve ailelerin de BİT kullanımına ilişkin farkındalıklarının artırılmasına yönelik projelere ihtiyaç duyulmaktadır. Bu araştırmada BİT'in kullanım şeklini ve başarısını etkileyen öğrencinin sosyo ekonomik geçmişi, yaşı ve cinsiyeti, öğrenme beklentileri gibi faktörler ele alınmamıştır. Bu değişkenler de modele eklenerek, BİT'in başarıya etkisini belirlemeye ilişkin çok düzeyli çeşitli çalışmalar yapılabilir.

Appendix. Tables Referenced in the Text

Table 1. The Correlation Matrix for the Level 1 and Level 2 Variables

Levels of Variables	Years	Predictor Variables	ICTHOME	ENTUSE	HOMSCH
The level 1 (student)	2009	ICTHOME	1		
		ENTUSE	.62	1	
		HOMSCH	.45	.63	1
	2012	ICTHOME	1		
		ENTUSE	.43	1	
		HOMSCH	.30	.53	1
Levels of variables	Years	Predictor variables	ICTSCH	USESCH	
The level 2 (school)	2009	ICTSCH	1		
		USESCH	.35	1	
	2012	ICTSCH	1		
		USESCH	.22	1	

Table 2. Fixed Effects Estimates and One-way Variance Analysis Random Effects Model

Fixed Effects	Coefficient	Standard Error	t-ratio	df
PISA 2009 average school mean, γ_{00}	436.12	5.94	73.36*	169
PISA 2012 average school mean, γ_{00}	439.90	5.71	77.04*	169

* $p < .001$

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

Outcome Variables	Random Effect	Standard Deviation	Variance Component	df	χ^2
PISA 2009 mathematics achievement	INTRCPT (School average), u_{0j}	76.13	5795.96	169	7039.26*
	level-1 effect, r_j	59.18	3502.58		
PISA 2012 mathematics achievement	INTRCPT (School average), u_{0j}	72.99	5327.39	169	8427.38*
	level-1 effect, r_j	56.20	3158.00		

* $p < .001$

Table 4. Interclass and Intraclass Correlation Coefficient Calculations

Mathematics Achievement Scores	Interclass and Intraclass Correlation Coefficient Calculations
PISA 2009 mathematics achievement	ρ (interclass) = $\tau_{00} / (\tau_{00} + \sigma^2)$ = 5795.96 / (5795.96 + 3502.58) = 0.62
	ρ (intraclass) = $\sigma^2 / (\sigma^2 + \tau_{00})$ = 3502.58 / (3502.58 + 5795.96) = 0.38
PISA 2012 mathematics achievement	ρ (interclass) = $\tau_{00} / (\tau_{00} + \sigma^2)$ = 5327.39 / (5327.39 + 3158.00) = 0.62
	ρ (intraclass) = $\sigma^2 / (\sigma^2 + \tau_{00})$ = 3158.00 / (3158.00 + 5327.39) = 0.38

Table 5. Estimation of Fixed Effects on Random Coefficients Model in the Student Level

Fixed Effects	Coefficient	Standard error	t-ratio	df	Effect Size
PISA 2009 mathematics achievement average, γ_{00}	436.08	5.95	73.31*	169	
Average ENTUSE effect, γ_{10}	3.85	0.92	4.17*	4510	.07
Average HOMSCH effect, γ_{20}	-8.77	0.99	-8.85*	4510	-.15
Average ICTHOME effect, γ_{30}	6.39	0.94	6.80*	4510	.11
PISA 2012 mathematics achievement average, γ_{00}	439.89	5.71	77.03*	169	
Average ENTUSE effect, γ_{10}	4.04	0.76	5.29*	4477	.07
Average HOMSCH effect, γ_{20}	-1.60	0.97	-1.65	4477	
Average ICTHOME effect, γ_{30}	2.71	0.84	3.24*	4477	.05

* $p < .001$

Table 6. Estimation of the Variance Components on Random Coefficients Regression Model in the Student Level

Outcome Variables	Random Effect	Standard Deviation	Variance Component	df	χ^2
PISA 2009 mathematics achievement	Level-2 error term, u_0	76.21	5807.83	169	7241.57*
	Level-1 error term, r_{ij}	58.36	3405.48		
PISA 2012 mathematics achievement	Level-2 error term, u_0	73.01	5329.93	169	8535.79*
	Level-1 error term, r_{ij}	55.84	3118.09		

* $p < .001$

Table 7. Fixed Effects for Mathematics Achievement in the Intercept and Slopes as Outcomes Model

Fixed Effects	Coefficient	Standard Error	t-ratio	df	Effect Size
PISA 2009 mathematics achievement average, γ_{00}	435.69	5.01	86.94*	167	
Average ICTSCH effect, γ_{01}	52.91	13.04	4.06*	167	.69
Average USESCH effect, γ_{02}	-76.32	14.64	-5.21*	167	-1.00
Average ENTUSE effect, γ_{10}	3.85	0.90	4.29*	4510	.06
Average HOMSCH effect, γ_{20}	-8.77	0.97	-9.02*	4510	-.14
Average ICTHOME effect, γ_{30}	6.39	0.91	7.04*	4510	.08
PISA 2012 mathematics achievement average, γ_{00}	438.30	4.77	91.82*	167	
Average ICTSCH effect, γ_{01}	60.76	10.34	5.88*	167	.83
Average USESCH effect, γ_{02}	-57.65	8.59	-6.71*	167	-.78
Average ENTUSE effect, γ_{10}	4.04	0.76	5.28*	4477	.07
Average HOMSCH effect, γ_{20}	-1.60	0.97	-1.65	4477	
Average ICTHOME effect, γ_{30}	2.71	0.84	3.23*	4477	.05

* $p < .001$

Table 8. Random Effects for Mathematics Achievement in the Intercept and Slopes as Outcomes

Variables	Random Effect	Standard Deviation	Variance Component	df	χ^2
PISA 2009 mathematics achievement	Level-2 error term, u_0	64.83	4203.46	167	5599.33*
	Level-1 error term, r_{ij}	58.36	3405.35		
PISA 2012 mathematics achievement	Level-2 error term, u_0	60.47	3656.48	167	5901.47*
	Level-1 error term, r_{ij}	55.85	3119.47		

* $p < .001$

Table 9. Likelihood Ratio Test Results of Outcome Variables

Variables	Compared models	Calculating of Likelihood Ratio Test and Results
PISA 2009 mathematics achievement	For goodness of fit of model 1 - model 4:	x_1^2 = (52139.20 - 51959.54) / (169 - 167) = 89.83
	For goodness of fit of model 2 - model 4:	x_2^2 = (52012.49 - 51959.54) / (169 - 167) = 26.47
	For goodness of fit of model 3 - model 4:	x_3^2 = (52086.26 - 51959.54) / (169 - 167) = 63.36
PISA 2012 mathematics achievement	For goodness of fit of model 1 - model 4:	x_1^2 = (51293.51 - 51177.37) / (169 - 167) = 58.08
	For goodness of fit of model 2 - model 4:	x_2^2 = (51236.54 - 51177.37) / (169 - 167) = 29.58
	For goodness of fit of model 3 - model 4:	x_3^2 = (51234.33 - 51177.37) / (169 - 167) = 28.48