INVESTIGATING THE ROLE OF COMPUTERIZED ASSESSMENT AND OTHER CORRELATES ON STUDENTS' SCIENCE PERFORMANCE IN PISA 2015

by

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ABSTRACT

INVESTIGATING THE ROLE OF COMPUTERIZED ASSESSMENT AND OTHER CORRELATES ON STUDENTS' SCIENCE PERFORMANCE IN PISA 2015

The aim of this study is to explore possible reasons for the decline in the Program for International Student Assessment (PISA) 2015 average science scores. Until 2015, the test was paper-based, but in 2015, for the first time, students took the test via computer. The decline was investigated based on data from Qatar, Peru, Turkey and Ireland as these countries represented various science scores and information and communication technologies (ICT) resources. By controlling student- and school-level variables, two-level regression was conducted for the analysis, taking into account plausible values and sample weights. The results indicated that there was a statistically significant positive relationship between ICT resources and science performance for Turkey and Peru, but not for Qatar and Ireland by controlling student- and school-level variables. On the other hand, almost all of the variables related to student characteristics were statistically significant predictors of science performance in these four countries, but significant variables related to school characteristics were different for each country. The science performance difference among schools was larger in Turkey compared to other countries. Overall, it could be concluded that the decrease in the PISA 2015 average science scores could be attributed to the computer based version of PISA as ICT resources were significant predictors for countries with low ICT resources when controlling major student and school level variables.

ÖZET

BİLGİSAYAR TABANLI SINAVIN VE DİĞER DEĞİŞKENLERİN PISA 2015 FEN BAŞARISINA ETKİSİNİN İNCELENMESİ

Bu çalışmanın amacı, Uluslararası Öğrenci Değerlendirme Programı (PISA) 2015 fen performansı ortalamasındaki düşüşün olası nedenlerini araştırmaktır. PISA, 2015 yılına kadar kâğıt-kalem testi olarak uygulanıyorken, 2015 yılında ilk kez bilgisayar ortamında uygulanmıştır. İrlanda, Peru, Türkiye ve Katar, ortalama fen performans ve Bilgi ve İletişim Teknolojileri (BİT) puanlarına bağlı olarak temsili ülkeler olarak seçilmiş ve analiz bu ülkeler üzerinden gerçekleştirilmiştir. Öğrenci ve okul düzeyindeki değişkenler kontrol edilerek, iki düzeyli regresyon analizi yapılmıştır. Olası değerler ve örneklem ağırlıkları da analize dahil edilmiştir. Analiz sonuçlarına göre, öğrenci ve okul seviyesindeki değişkenler sabit tutulduğunda, Türkiye ve Peru için BİT kaynakları ve fen performans arasında istatiksel olarak anlamlı bir ilişki gözlenirken, Katar ve İrlanda için istatiksel olarak anlamlı bir ilişki gözlenememiştir. Öte yandan, neredeyse öğrenci seviyesindeki tüm değişkenler seçilen dört ülke için istatiksel olarak anlamlı çıkarken, okul seviyesindeki değişkenlerin istatiksel olarak anlamlı oluşu dört ülke için değişiklik göstermiştir. Okullar arası başarı farkı en fazla Türkiye'de olduğu görülmüştür. Genel olarak, okul ve öğrenci seviyelerindeki değişkenler sabit tutulduğunda, düşük BİT kaynaklarına sahip ülkeler için istatiksel olarak anlamlı bir değişken olduğu için, PISA 2015 sınavının bilgisayar tabanlı oluşunun fen performans ortalamasındaki düşüş ile ilişkili olduğu söylenebilir.

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LIST OF ACRONYMS/ABBREVIATIONS

ICT	Information and Communication Technologies
OECD	Organization for Economic Cooperation and Development
PISA	Program for International Student Assessment
SD	Standard Deviation
SE	Standard Error
ZPRED	Regression standardized predicted value
ZRESID	Regression standardized residuals

1. INTRODUCTION

1.1. Importance of Science Literacy

In the contemporary world, educational policy has gradually increased the importance placed on developing students' academic skills and literacy (Ramirez, Luo, Schofer, & Meyer, 2006). In this regard, science helps people to comprehend and deal with economic, social, and environmental challenges of globalization by improving their critical thinking and training them to make informed evaluations in their daily lives (Royal Society, 2014). The Organization for Economic Cooperation and Development (OECD) (2016a) refers to this situation thus: "At a time when science literacy is increasingly linked to economic growth and is necessary for finding solutions to complex social and environmental problems, all citizens, not just future scientists and engineers, need to be willing and be able to confront science-related dilemmas" (p.6). Therefore, students' science performance is a crucial concern for all countries and international large-scale assessments are used to compare educational systems around the world in order to understand which systems are more effective and provide the most viable ways to improve the science literacy skills of students.

1.2. Importance of Program for International Assessment (PISA)

The Programme for International Student Assessment (PISA), which is conducted by the OECD, is one of the several large-scale international assessments like Trends in International Mathematics and Science Study (TIMSS), and Progress in International Reading Literacy Study (PIRLS). Administered triennially, PISA measures students' capabilities in three disciplines (reading literacy, mathematical literacy, and scientific literacy) and gathers data about student, parent, and school characteristics at the international level (OECD, 2016b, 2017a). The importance of PISA comes from its multidimensional aspects. It creates an occasion for comparisons for the three disciplines, among others, not only cross-nationally, but also at many other levels, such as at the level of students, parents, and schools.

The PISA tests were paper-based until 2015; in that year, almost all countries administered the tests using computers for the first time (Kastberg, Chan, & Murray, 2016), and in this year science performance and the OECD average dropped to a minimum level since its first cycle. Theoretically, there is no lowest or highest score in PISA. The scores are published as normal distribution with average 500 score points for OECD countries and 100 score points standard deviation (OECD, 2017a). The OECD overall average science scores were 500 in 2003; 498 in 2006; 501 in 2009; 501 in 2012; and 493 in 2015.

1.3. The Purpose of the Study

The purpose of this study was to examine the role of access to ICT resources at homes and other correlates on the science performance of students in PISA 2015.

Students' familiarity with information and communication technology (ICT) might affect their usage of computers during the test. If students are not familiar with ICT resources beforehand, they might not have enough knowledge and skills for the computer use required by the exam.

1.4. Determination of the Countries for this study

There are many countries that take the PISA test and to analyze and interpret data from all countries at the same time could not be possible. Therefore, four countries -Ireland, Peru, Turkey, and Qatar- were determined as representatives. These countries were selected by investigating their science scores and ICT resources. So, first of all, the relationship between countries' science performance and their access to ICT resources at homes in PISA 2015 was analyzed. As shown in Figure 1.1, based on the preliminary analysis, there is a significant relationship between the PISA 2015 scores and access to ICT resources.

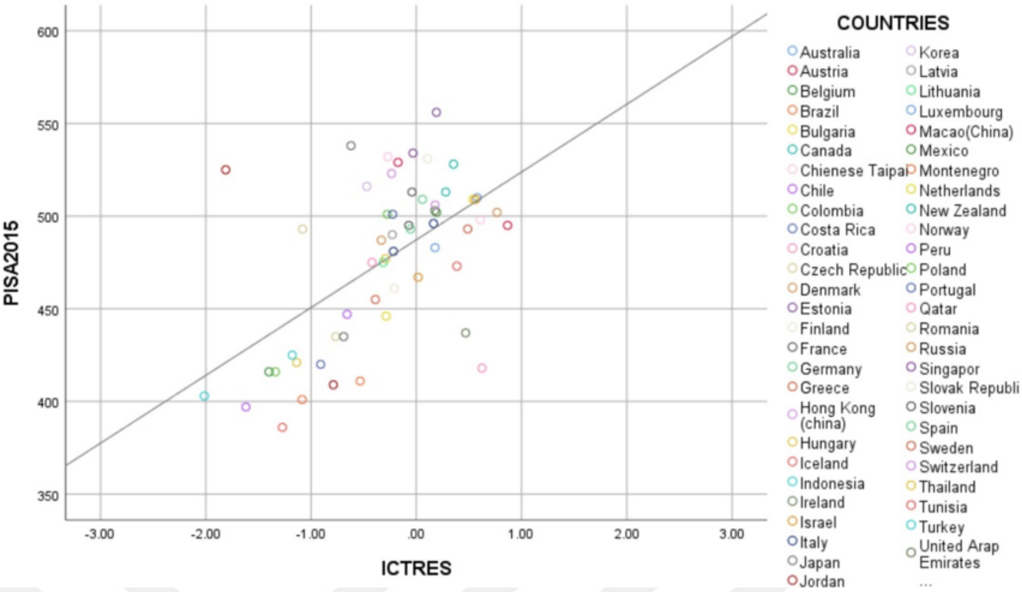

Figure 1.1. The relationship between countries' science performance and their ICT resources scores in PISA 2015.

After the preliminary analysis of was conducted, the difference between mean PISA 2015 and PISA 2012 science performance scores of participated countries was calculated on the Microsoft Excel. Secondly, ICT resources scores in PISA 2015 of the countries were added the next column in order to draw a graph. Then the graph of the countries' science performance scores difference between PISA 2015 and PISA 2012 and ICT resources scores was drawn as seen in Figure 1.2. After the graph was drawn, the countries with the greatest increases or decreases in science performance averages and those with anomalous ICT resources scores on the PISA 2015 were chosen. Qatar was chosen because this country had the most increase in students' science performance average with positive ICT resources average. Peru was chosen because this country had the most increase in students' science performance average with negative ICT resources averages. Turkey was chosen because this country had the most decrease in students' science performance averages with negative ICT resources. Finally, Ireland was chosen because this country had the most decrease in students' science performance average with positive ICT resources average as seen in the Figure 1.2. Therefore, these countries assumed to represent general trend regarding the relationship between science scores and ICT recourses. The plausible value difference and ICT resources scores in PISA

2015 of the countries are available in Appendix A. All the data were taken from OECD website (OECD, 2019a).

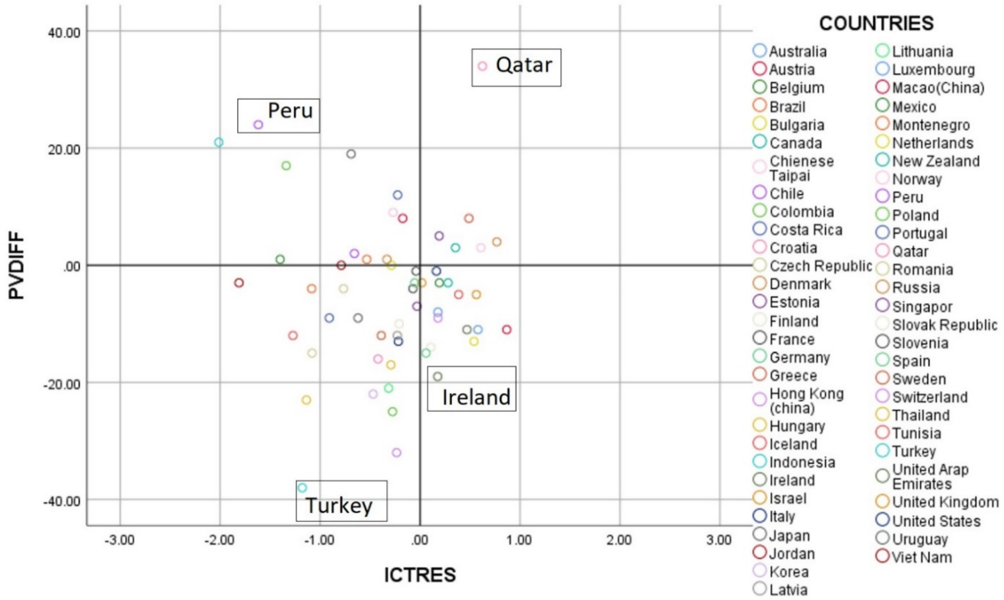

Figure 1.2. The relationship between the plausible value differences of countries between PISA 2015 and PISA 2012 and their ICT resource averages from the PISA 2015.

1.5. Significance of the Study

This study investigated the relationships between students' science performance and their experiences with ICT resources while controlling for student and school characteristics, using the PISA 2015 data from Qatar, Peru, Turkey, and Ireland. As the aim of this study is to explain the relationship between ICT resources and other correlates, and science performance of students in PISA 2015, the four countries were chosen from the graph as shown in Figure 1.2. This study is unique because it compares the impact of ICT resources on science performance in four diverse countries, and the results may help explain to policymakers the importance of access to ICT and provide data on which future educational policy decisions can be based.

1.6. The Research Questions

Delineating which factors are related to students' science performance is necessary because of the importance of the science literacy. In the cycle of 2015, the test was given to students as computer-based and in the year, 2015, OECD's science performance average fell to the minimum level. The following research questions were determined to understand possible reasons for the decline in PISA 2015 science performance scores of students:

(i) Which student-level variables - self-efficacy, enjoyment of science, instrumental motivation, epistemological beliefs, science related activities, test anxiety, motivation to achievement, sense of belonging to school, disciplinary classroom environment, parental emotional support, parent's education levels, cultural possession at home, inquiry based and teacher directed learning environments - could predict PISA 2015 science performance of students in Ireland, Peru, Turkey, and Qatar?

(ii) Which school-level variables - classroom size, shortage of educational staff, shortage of educational materials, science-specific resources, the number of computers available per student at model grade, the index proportion science teachers by all teachers, the index proportion of the proportion of fully certificated science teachers, and the index of the proportion of science teachers with International Standard Classification of Education (ISCED) level 5A (Theoretically oriented tertiary) and a major in science - could predict PISA 2015 science performance of students in Ireland, Peru, Turkey, and Qatar?

(iii) What is the role of ICT resources in predicting science performance of Qatar, Peru, Turkey, and Ireland when controlling student- and school-level variables?

1.6.1. Statement of the Research Hypothesis

(i) Student level variables including self-efficacy, enjoyment of science, instrumental motivation, epistemological beliefs, science related activities, test anxiety, motivation to achievement, sense of belonging to school, disciplinary classroom environment, parental emotional support, parent's education levels, cultural possession at home, inquiry based and teacher directed learning environments predict PISA 2015 science performance of students in Ireland, Peru, Turkey, and Qatar.

(ii) School level variables including classroom size, shortage of educational staff, shortage of educational materials, science-specific resources, the number of computers available per student at model grade, the index proportion science teachers by all teachers, the index proportion of the proportion of fully certificated science teachers, and the index of the proportion of science teachers with International Standard Classification of Education (ISCED) level 5A (Theoretically oriented tertiary) and a major in science predict PISA 2015 science performance of students in Ireland, Peru, Turkey, and Qatar.

(iii) Having ICT resources at homes predict PISA 2015 science performance of students in Ireland, Peru, Turkey, and Qatar when controlling for school- and student-level variables.

2. LITERATURE REVIEW

2.1. Organization for Economic Co-operation and Development (OECD)

The Organization for Economic Co-operation and Development was established on 30 September 1961 to develop policies about the economic, social, and environmental well-being of people across the world. The OECD also helps to comprehend the problems related to economy, environment, and issues directly impacting people's daily lives such as school systems, agriculture, and the safety of chemicals at international levels.

The OECD has currently 36 member countries. These are Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States (OECD, 2018).

2.2. Science Performance in PISA

PISA is a large-scale test conducted by the OECD. In PISA, scientific literacy of students is measured for scientific performance. Scientific literacy is defined as the ability of using scientific knowledge to determine questions, to obtain new knowledge, to clarify scientific phenomena, and to make evidence-based deductions about science-related matters. The mean score is the measure of scientific performance (OECD, 2019b). PISA uses the term "literacy" because it measures students' competencies to implement scientific knowledge into their daily life problems and situations without giving importance to specific curricula of any country (Anderson, Lin, Treagust, Ross, & Yore, 2007). The scientific literacy term is also defined by OECD (2017a) as:

The ability to engage with science-related issues, and with the ideas of science, as a reflective citizen. Along that line, a scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to:

- Explain phenomena scientifically - recognize, offer and evaluate explanations for a range of natural and technological phenomena.
- Evaluate and design scientific inquiry - describe and appraise scientific investigations and propose ways of addressing questions scientifically.
- Interpret data and evidence scientifically - analyze and evaluate data, claims, and arguments in a variety of representations and draw appropriate scientific conclusions.

2.3. Equality of Educational Opportunity

The equality of educational opportunity means that after changing a child's place from a family or an organization to "a most differential and unequal" environment, that setting is the same for all children (Coleman, 2019). Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld, and York (1966) conducted a study in the U.S. by gathering data from 4.000 public schools. They compared 3rd, 6th, 9th, and 12th grade students' academic achievement in terms of school characteristics such as physical facilities of the schools, the academic and extracurricular activities in the schools and student characteristics such as their race/ethnicity, socioeconomic background, their parents' education level, and collected information on materials in their homes like newspapers, encyclopedias. While school-based information was supplied by the teachers and administrators, personal information was given by students. Additionally, teachers and administrators also released information about their educational background, their own experience, and socioeconomic background of the school district and pupils gave the information about their academic targets and attitude towards schools. They collaborated with the National Center for Educational Statistics of the U.S. Office of Education for implementing the survey. According to the results, school facilities and curricula have a smaller effect than the quality of teachers, educational backgrounds and aspirations of other pupils in the schools depending on race and ethnicity of students such as African Americans and whites. The most crucial result was that differences among students within the same school were "roughly four times large" than the differences between schools (Coleman *et al.*, 1966). Thus, Coleman *et al.* (1966) showed that the impact of students' personal factors is clearly greater than school-based factors on academic achievement of students.

There are some other studies supporting Coleman *et al.*, (1966) results. For example, the Polaman Report (Peaker, 1967) showed the importance of parental factors such as attitudes than the variation in schools in British society. The analysis of the report found the parental support is partly related to the material circumstances of the families. Additionally, Börkan and Bakış (2016) conducted research on the effective factors to 7th and 8th grade Turkish students by using e-school data. They found that 73% of the between-school variance was accounted for through student-level variables such as income levels and education levels of parents, gender and so on, which also showed that school-based variables explained only 5% of the difference among pupils' academic achievement (Börkan & Bakış, 2016).

2.4. The Heyneman-Loxley Effect

Heyneman and Loxley (1983) found a correlation between the income levels of countries and the academic achievement of students. The available data shows that in low-income countries while the school and teacher quality have a huge impact on pupils' academic achievement rather than their social status. They used six different sources for twenty-nine countries in Africa, Asia, Latin America, and the Middle East. While eight of the countries were low-income, nine of these countries were middle-income, and twelve of them were high-income countries. The questionnaires were taken from students, teachers, and administrators through a mail survey. The information was about from students' characteristics such as social and economic backgrounds to school characteristics such as resources, facilities and teachers' qualities (Heynaman

& Loxley, 1983). They showed the impact of school-based factors on the academic achievement of students than their personal characteristics depending on the income levels of countries. The income levels of countries were related to the Gross National Income (GNI) levels of them.

However, Baker, Goesling, and Letendre (2002) tested the theory by using the Third International Mathematics and Science Study (TIMSS) 1994 data. They analyzed the theory with thirty-six countries' results, and they realized that there is an increasing impact of family-background on academic achievement in poorer nations. Similarly, Alacacı and Erbaş (2010) found that not only school characteristics but also students' family SES are two crucial factors for academic achievement in Turkey. According to the result of this study which is conducted by Alacacı and Erbaş (2010), while the school effect is 55% on students' mathematics achievement, the student characteristics are 45% based on PISA 2006 Turkey data.

2.5. The Variables Depending on the Theories of Equality of Educational Opportunity and Heyneman-Loxley Effect

The conceptual framework of this study were created based on the theories of Equality of Educational Opportunity and Heyneman-Loxley effect. PISA 2015 science plausible values were dependent variables. Student- and school- levels variables were independent variables. As shown in Figure 2.1, student level variables were chosen under the four titles which are students' science attitudes factor, students' personal factors, students' considerations about classroom learning environments, and parental factors. At the same time, school level variables were investigated under two categories which are physical factors of schools, and teacher-related factors.

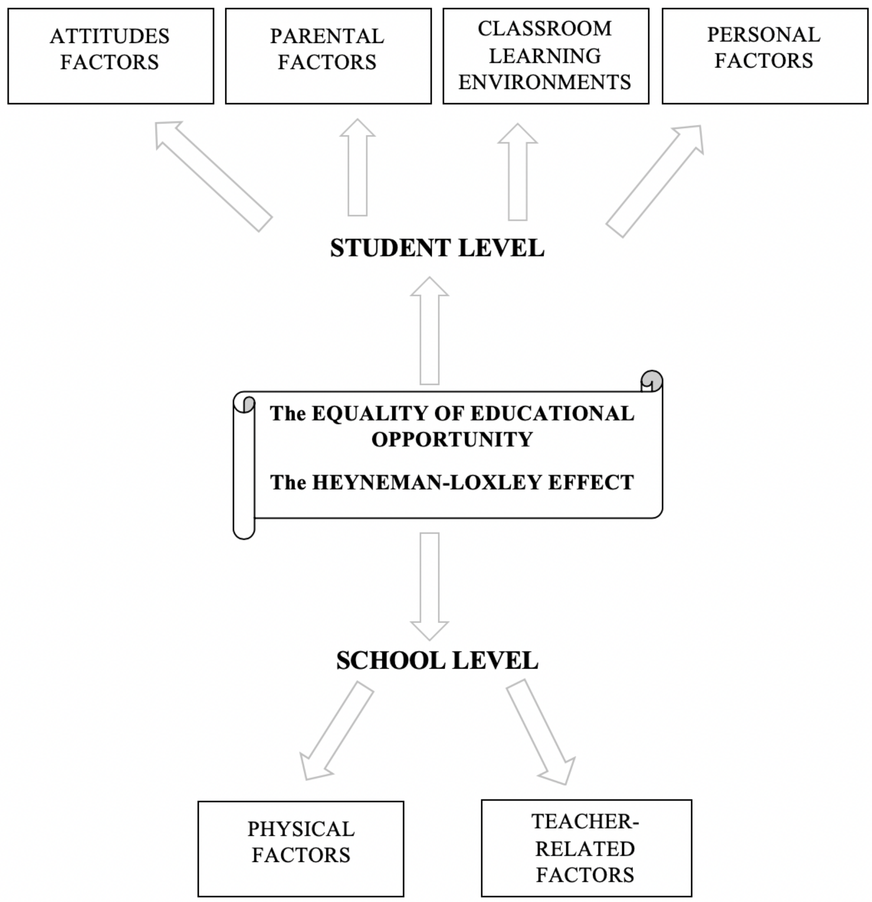

Figure 2.1. The conceptual framework of this study.

2.5.1. The Investigation of Student-Level Variables

Many studies highlight the importance of student level variables such as students' attitudes factors, personal factors, students' concerns about classroom learning environment, and parental factors on their academic achievement (Acar & Öğretmen, 2012; Chiu, 2007; Coleman *et al.*, 1966; Demir, Kılıç, Depren, 2009; Fonseca, Valente, & Conboy, 2011; Fuchs & Wößmann, 2004; Grabau & Ma, 2017; Martins & Veiga, 2010; Tomul & Çelik, 2009).

In the literature, the index of economic, social, and cultural status (ESCS), home possession (HOMEPOS), family wealth (WEALTH), home educational resources (HEDRES) are important predictors of science performance of students (Demir, Kılıç,

& Ünal, 2010; Dolu, 2018; Fonseca *et al.*, 2011; Fuchs & Wößmann, 2004; Gürsakal, 2012; Marks, Creswell, & Ainley, 2006; Türkan, Üner, & Alcı, 2015). However, there are common indicators between ICT resources (ICTRES) and cultural possession at home (CULTPOSS) and, ESCS, home possessions, and family wealth variables. Therefore, ESCS, home possessions, and family wealth were excluded from this study. The table of the indicators of these household possessions and home background indices are given in the Appendix B. Detailed information about all selected variables for these titles in this study are given below.

2.5.1.1. Students' Attitudes Factors. There are many studies that show the importance of students' science engagement such as science self-efficacy, enjoyment of science, instrumental motivation, science-related activities on their science performance for a lot of countries such as U.S (Grabau & Ma, 2017), Canada (Areepattamannil, Freeman, & Klinger, 2011), Hong Kong (Sun, Bradley, & Akers, 2012), Turkey, Finland, Greece, Portugal, Spain, United Kingdom (Fonseca *et al.*, 2011).

Self- efficacy is about person's confidence on his or her capacity to succeed a task affecting his/her life under certain conditions (Bandura, 1994; Maddux, 2002). Bandura (1994) stated that people who have strong self-efficacy can accomplish complex tasks, reach their targets, and have capabilities more than the people who have low self-efficacy. On the other hand, Bandura (1994) gave the four ways of improving self-efficacy of people: "mastery experience, vicarious experience, social persuasion, and psychological and emotional states". Related to the perspective, the term has been defined in science as students' self-reliance in science-related tasks, science courses, and scientific issues (Areepattamannil *et al.*, 2011; Grabau & Ma, 2017). Aurah (2017) found a high correlation between self-efficacy and academic achievement of 12th grade Kenyan students. Science self-efficacy positively and statistically significantly related to science performance of also American (Grabau & Ma, 2017), Canadian (Areepattamannil *et al.*, 2011), and Portuguese (Fonseca *et al.*, 2011) students based on PISA 2006.

Enjoyment of science means how much students feel enjoyment while learning and experiencing science-related activities and topics (Shumow, Schmidt, & Zaleski, 2013). Ryan and Deci (2000) stated that it is intrinsic motivation. Hampden- Thompson and Bennett (2013) also accepted enjoyment of science as an aspect of emotional engagement. They found that "interaction, hands-on activities, and applications" as kinds of teaching and learning activities in science classes related to enjoyment of science (p.16). It is a significant variable that affecting students' science performance not only for the countries of Greece, Turkey, the United Kingdom but also for Finland, and Spain (Fonseca *et al.*, 2011).

Instrumental motivation is described as students' belief in towards science that it will be needed and effective for their future and careers (OECD, 2016b). Instrumental motivation is also accepted as extrinsic motivation (Areepattamannil *et al.*, 2011; Kula-Kartal & Kutlu, 2017) and cognitive engagement (Hampden-Thompson & Bennett, 2013). Hampden- Thompson and Bennett (2013) found that also instrumental motivation related to "interaction, hands-on activities, and applications". On the other hand, instrumental motivation is a controversial issue. For example, according to Kula-Kartal and Kutlu's (2017) study, the importance of the instrumental motivation changes depending on the level of the Turkish students in PISA 2015. While Fonseca *et al.* (2011) found the negative association between instrumental motivation to science and science performance of American students, Grabau and Ma (2017) found a positive and medium significant relationship between them based on PISA 2006 results of U.S.

Epistemological beliefs about science are related to students' beliefs about scientific knowledge, learning, and methods for comprehension the reality (OECD, 2016b; Peer & Atputhasamy, 2005). According to the OECD (2016b), students' epistemic beliefs about science-related topics created 12% variance in science performance scores of students except for countries of Algeria, Costa Rica, the Dominican Republic, Indonesia, Kazakhstan, Mexico and Tunisia. In these countries, the variance is less than 6%.

The concept of science-related activities is about the students' preference for scientific activities outside the school (Grabau & Ma, 2017). The concept positively and statistically significantly related with the science performance of students in the U.S. (Grabau & Ma, 2017), negatively related with science performance of students in Greece, Portugal, and Spain, and not significantly related with science performance of students in Finland, United Kingdom, and Turkey based on PISA 2006 (Foncesa *et al.*, 2011).

2.5.1.2. Students' Personal Factors. Test anxiety, motivation to achievement and sense of belonging are predicting variables to students' science performance (OECD, 2016b).

One of the definitions for test-anxiety was given by Spielberger (1980) as worry of student for any kind of exams at any grades. Test anxiety is negatively related to the science performance of students also in almost all countries participating in PISA 2015 (Ergene, 2011; OECD, 2016b). While the ratio is 63% of the students with low grades, 46% of students with high grades across OECD countries (OECD, 2016b). According to the OECD (2019c), one of the possible reasons for the test anxiety is high motivation to achievement, especially extrinsic motivation created by parents or teachers on students.

Motivation to achievement is a significant concept for explaining academic achievement of students (Shen Jen, & Seng Yong, 2013; Steinmayr, Weidinger, Schwinger, & Spinath., 2019). For example, OECD (2019c) found positive relationship between motivation to achievement and performance of 15-year-olds in almost all countries in PISA 2015. Highly motivated students have better scores than others in their own countries except Singapore and Belgium (OECD, 2019c). Based on the OECD's report (2019c), socio-economic levels of both students and schools affect motivation of students. In the report, trust and expectations of adults in the students' lives who have advantages environments in their homes and schools, and awareness about chance for future occupations the possible reason for the situation were stated as possible reason for the affecting factors of motivation to achievement of students.

Sense of belonging to school is positively related to academic achievement of students (Roeser, Midgley, & Urdan, 1996; St-Amand, Girard, & Smith, 2017). Osterman (2000) expressed its importance as that "belongingness is an extremely important concept. As a psychological phenomenon, it has far reaching impact on human motivation and behavior". OECD (2017b) found positive relationship between life satisfaction of the students and sense of belonging to school. For example, students who feel as an "outsider" at their school have lower life satisfaction more than four times compared to others in Finland, Ireland, Korea, the Netherlands, the United Kingdom, and the United States. St-Amand, Girard, and Smith's (2017) literature review showed that positive relationship with teachers and staff including active listening, academic, and personal support of students, collaborative and teamwork studies as effective teaching strategies, and students' attendance in extracurricular activities are ways of improving students' sense of belonging to school.

<u>2.5.1.3. Classroom Learning Environments.</u> One of the crucial school-based variables which influences science achievement is the classroom learning environment (Anderson *et al.*, 2007; Bybee, McCrae, & Laurie, 2009). The research in which the PISA 2006 dataset was used shows that there is a significant difference among students who have an inquiry-based learning environment and others in terms of science achievement (Anderson, *et al.*, 2007). Moreover, another analysis which included 14 European Union Member States - Croatia, Czech Republic, Finland, France, Germany, Greece, Italy, Lithuania, Luxembourg, the Netherlands, Portugal, Slovakia, Spain and the United Kingdom -based on PISA 2015 data shows that inquiry-based learning environment promotes science achievement of students (Costa & Araújo, 2018). Inquiry-based learning environment requires active involvement of students in their processes of knowledge acquisition (de Jong, & van Joolingen, 1998; Pedaste, Maeots, Siiman, de Jong, van Riesen, Kamp, Manoli, Zacharia, & Tsourlidaki, 2015) like scientists' work (Abdi, 2014). Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, & Landes (2006) created

the 5E instructional model which has five main steps for inquiry-based learning environment including engagement, exploration, explanation, elaboration, and evaluation. Roots of the model come from Herbart's instructional Model (1901), Dewey's Instruction model, especially the Science Curriculum Improvement Study (SCIS) learning cycle (Karplus & Thier, 1967). Pedaste *et al.* (2015) give a way of creating inquiry-based learning environment as "to leave more freedom to the learners while guiding them toward a productive learning process based on the specific issues that have been detected during the learning process" (p.58). Although there is much research about positive relationship between science performance of students and inquiry-based learning environment, the issue is controversial (Cairns, 2019). For example, Cairns and Areepattamannil (2019) conducted a study including 54 countries from third cycle of PISA and found the statistically significant and negative relationship between the inquiry-based science instruction and science performance of students. Their study promotes OECD's (2016b) results.

2.5.1.4. Students' Parental Factors. There are many studies analyzing the effect of parental factors such as parental emotional support (Perera, 2014), parents' education (Fuchs & Wöbmann, 2004; Güzeller & Şeker, 2016; Tomul & Çelik,2009), cultural possessions at home and ICT related variables (Aypay, 2010; Delen & Bulut, 2011; Demir, Kılıç, & Ünal, 2010; Gümüş & Atalmış, 2011; Güzeller & Akın, 2014; Hu, Gong, Lai, & Leung, 2018; Mechlova & Malcik, 2012; Petko, Cantieni, & Prasse, 2017; Přinosilov*aá*, Mechlová, & Kubicová, 2013; Zhang & Liu, 2016) by using PISA datasets across different countries.

Related with Tomul and Çelik's (2009) study, Güzeller and Şeker (2016) found a statistically significant relationship between mothers' and fathers' education levels and students' science performance based on PISA 2006 and PISA 2009 respectively. When the educational levels of both mothers and fathers increase, the science performance of their children also increase. Gürsakal (2012) analyzed PISA 2009 in terms of the relationship between the performance of students in reading, mathematics, and science and educational levels of parents. The results showed that they are positively correlated. When both mothers' and fathers' education levels increased, the academic achievements of students in three areas increased. Fuchs and Wobmann (2004) used the PISA 2000 results which included 32 participating countries for analyzing the impact of parents' education level on academic achievement of students. They found a 34.3 achievement point (AP) difference in reading, 26.9 in math, and 26.5 in science between students who have parents graduated from university and students whose parents did not finish primary education.

Parents' emotional support means that parents endorse their children's educational activities (Acharya, &Joshi, 2011). Beyer (1995) found parents' communication with their children by verbal support, showing interest their school performance, and praising their endeavors contribute pupils' school performances. Acharya and Josji (2011) found significant positive correlation between parents' emotional support and academic achievement of 11th and 12th grades Hindustani students. Parents' attitudes toward science which could affect their emotional support to science education of their children was a statistically significant predictor for science performance of students not only for Hong Kong (Sun *et al.*, 2012) but also for Colombia (Latin America), Bulgaria, Croatia, Denmark, Germany, Iceland, Italy, Luxembourg, Portugal and Turkey (Europe and Central Asia), Qatar (Middle East), Macao and South Korea (Asia) and New Zealand (Oceania) (Perera, 2014).

Cultural possessions at home is related to the books on poetry, art, music, design, musical instrument and classic literature. Because the variable is also accepted as a way of socioeconomic status of the families, there is limited research on the effect of cultural possession at home on academic achievement or performance of students. One of the studies conducted by Topçu, Arıkan, and Erbilgin (2015) found that while having classic literature is positively and significantly related with science performance of students, having poetry books are negatively and significantly related with science performance of Turkish students in PISA 2006 and 2009. Gilleece, Cosgrove, and Sofroniou (2010) accepted classic literature, poetry works, and works of art as cultural capital and analyzed index variable using Ireland datasets in PISA 2006. The result of this study shows that cultural capital of students is a statistically significant variable for predicting science performance of Irish students (Gilleece *et al.*, 2010).

There are many studies on how ICT affects academic performance of students, especially based on PISA results. Many of these studies are about students' aims while using ICT at their homes or schools such as the entertainment use, the program/software use, and the use of ICT at home for school related purposes (Aypay, 2010; Delen & Bulut, 2011; Demir, Kılıç, & Ünal, 2010; Gümüş & Atalmış, 2011; Güzeller & Akın, 2014; Mecholova & Malcik, 2012; Petko, Cantieni, & Prasse, 2017; Přinosilovaá, Mechlová, & Kubicová, 2013; Zhang & Liu, 2016) rather than their access to ICT resources at their homes. Hu, Gong, Lai, and Leung (2018) conducted the research about the relationship between ICT and students' literacy in mathematics, science, and reading across 44 countries by using PISA 2015 results. According to the result of this study of Hu *et al.* (2018), while students' availability to ICT at school positively related to their academic performance, their ICT availability at home negatively related to students' academic performance. Topçu *et al.* (2015) found that students' number of computers at home is positively and significantly related to science performance of Turkish students both in PISA 2006 and 2009.

2.5.2. The Investigation of School-Level Variables

Schools affect students' academic achievement in almost all countries to different degrees (Acar & Öğretmen, 2012; Alacacı &Erbas, 2010; Baker *et al.*, 2002; Heyneman & Loxley, 1983; Martins & Veiga, 2010). For example, the OECD average between-school variance is 37% and Turkey's average between-school variance is 55% based on PISA 2006 (Alacacı & Erbaş, 2010).

<u>2.5.2.1. Physical Factors.</u> Physical factors such as shortage of educational staff, educational materials and science-specific resources of school are related factors not only with science performance of the students but also mathematics and reading performance of the students in India based on PISA 2009 results (Areepattamannil, 2014). Sousa, Park, and Armor (2012) found that physical factors are significantly related to

academic performance of students in Korea, Japan, Canada, Austria, Germany, the United Kingdom, Spain, and Italy, France based on both PISA 2006 and PISA 2009 results. Additionally, the factors also related to American students' academic performance based on both PISA 2006 and PISA 2009 datasets (Grabau, 2016; Sousa *et al.*, 2012).

2.5.2.2. Teacher-related Factors. There are different results for the relationship between the science performance of students and teachers' certification levels (Fuchs & Wößmann, 2007; Grabau, 2016; Sharkey & Goldhaber, 2008). While Fuchs & Wößmann (2007) found a positive correlation among them across 31 countries in PISA 2000, Sharkey and Goldhaber, (2008) did not find any correlation between these two variables in U.S. private high schools seniors (Grabau, 2016).

2.6. Characteristics of the Countries

2.6.1. Educational Systems of the Countries

Compulsory school years, levels, and educational systems of countries can differ with each other. So, the educational systems of the four countries are examined in this section.

2.6.2. Region and Economic Status of the Countries

World Bank classifies countries as seven groups which are East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, North America South Asia, and Sun-Saharan Africa according to the locations of countries.

World Bank also classifies the developmental levels of countries according to the Gross Domestic Product (GDP) of them. There are mainly three levels which are the least developed countries, developing countries, and developed countries. On the other hand, there are four categories based on income-levels of countries which are low-income countries, lower-middle-income countries, upper-middle-income countries, and high-income countries. These categories are classified according to the Gross National Income (GNI) levels of countries. If GNI of a country is $1,025 or less, it is a low-income economy; between $1,026 and $3,995, lower-middle-income economy; between $3,996 and 12,375, upper-middle-income economy; $12,376 or more, high-income-economy.

2.6.2.1. Ireland. Ireland is in Europe and Central Asia. It is a developed country with its high-income-economy level.

The primary language of schools is Irish, and English is a second language. Compulsory education years are from the ages of six to 16 or at the end of three years of second-level education in Ireland. Preschool education years are optional and there are infant classes in primary schools for four- and five-years old children. Although preschool education is optional, 40% of four-year-old children and almost all five-year-old children attend. (Department of Education and Skills, 2020). Until the age of 12, students go to primary schools named “junior infants, senior infants, and first to six classes” (Department of Education and Skills, 2020). Primary schools are private, state-funded, and special. At the age of 12, students start a three-year lower secondary (Junior cycle) and then they take two- or three-years with optional Transition Year (TY) in upper secondary (Senior cycle). TY enables students to gain work or other experiences. Post primary schools are private secondary schools, public Education and Training Boards (ETBs) schools, and community schools which are administered by Boards of Management of different compositions. During the last two years of upper secondary school years students take one of the three certificates which are called “The Leaving Certificate, The Leaving Certificate Vocational Programme, and The Leaving Certificate Applied Programme” based on a state examination. The Leaving Certificate Vocational Programme is similar with The Leaving Certificate, but it focuses on technical topics and vocational modules. The last programme is for students who cannot receive other leaving certificate programmes. Therefore, the certificate includes “person-centered courses rather than a subject based structure”. As higher education, students mainly go to the Institute of Technology, Universities, and the Colleges of Education.

There is Social Inclusion Unit who is in charge of improvement and supporting educational disadvantages during both preschool years and compulsory education years (Department of Education and Skills, 2020). Additionally, Science, Technology, Engineering, and Mathematics (STEM) Education Review Group was established by The Ministry for Research and Innovation at November 2013 in order to examine STEM education especially at primary and post primary education years (Department of Education and Skills, 2013).

2.6.2.2. Peru. Peru is in Latin America and The Caribbean. It is a developing country with its upper-middle-income economy level.

Spanish is the language of the education in Peru (Clark, 2015). Compulsory and free school years are 12 years from five to 16 in Peru. The first year in preschool education starts at age of five. Then, there are six years of primary school education period at age of six to 11. At the age of 12 and 16, there are five years of secondary school years. Students can prefer Technical and Vocational schools which are usually private, rather than secondary schools. After students graduated from the schools, they are awarded Assistant Technician or Technician Certificates based on education years. For the first two years of secondary education, schools have a general education curriculum. At the age of 14, students choose academic or technical streams. Both of these areas provide access to university. There are private and public schools at all levels and both public and private schools have a common national curriculum. There are four levels in education which are primary, secondary, vocational and technical, and university (Clark, 2015).

Ministry of Education is responsible for all educational activities. The National Super intendency of University Higher Education (SUNEDU) is a new higher education authority since January 2015 (Clark, 2015).

2.6.2.3. Turkey. Turkey is in Europe and Central Asia. It is a developing country with its upper-middle-income economy level. The primary language of education is Turkish, and foreign language education starts at second grade primary in the primary school. The second language is usually English, but there are different options as part of the living languages and dialects course such as Arabic, German, and French.

Ministry of Education is responsible for all educational activities in Turkey. There is 12 years of compulsory and free education in Turkey, starting from primary education (one to four grades), middle school (five to eight grades), and high school (nine to 12 grades). Additionally, preschool education is also compulsory for students who need special education.

Early childhood education is for children who are from zero to 36 months at day nurseries. Ministry of family and social policies is responsible for early childhood education. There are kindergartens for children who are ages 30 to 66 months. Primary education years are from 66 months to 10 years old. There are two kind of middle schools which are Imam Hatip middle schools and middle schools. High schools are Anatolian High Schools, Science High Schools, Fine Arts High Schools, Social Science High Schools, Vocational and Technical High Schools, and Imam Hatip High Schools. In the 9th grade, all schools have the same curriculum and after the 9th grade, there are some differences among schools based on their establishment aims. For example, in Anatolian High Schools, students decide their specialization as Turkish and Mathematics, Mathematics and Science or Language based at the end of their second years, however, in Vocational and Technical High Schools, students select their specializations based on professions at the end of their first-year education because in these schools, there are compulsory internships after the first year according to students' selected occupations. In the Imam Hatip High Schools, there are Islam religion-based courses such as Islamic law, Arabic, the Koran, and Hadith in addition to the other courses such as science and mathematics courses. In science high schools, the number of chemistry, biology, physics, and mathematics are more than other courses such as language, and physical education lesson. Pupils who are ages from 14 to 17 go to the one of the schools. Based on the university entrance exam at the end of high schools, students can go state, foundation, or private universities. Council of higher education is responsible for organization of all activities for higher education.

General Directorate for special education guidance and counseling service is responsible for all students who need special education.

2.6.2.4. Qatar. Qatar is in the Middle East and North Africa region. It is a developed country with its high-income economy level.

The education system is managed by the Ministry of Education and Higher Education (MoE-HE) in Qatar (Fadlelmula & Koç, 2016). The official language and the language of instruction is Arabic. The foreign language is English in all schools and the medium of language is English also in most of the international schools (Mullis, Martin, Goh & Prendergast, 2017).

Pre-school years are from the age of 3 to 5 in Qatar and these schools are private. At the age of 6, compulsory school years start, and the period is six years and free, which is called primary education from one to six grade. Primary schools are private or public schools. Students can go to a university after completing three years of preparatory education from seven to nine grade, and three years of secondary education or from ten to 12 grade. Preparatory schools are private or public, but all schools have a standard academic curriculum (Fadlelmula & Koç, 2016).

"Among Gulf Cooperation Council (GCC) countries (Bahrain, Saudi Arabia, United Arab Emirates, Oman, and Kuwait), it is the only country where girls' net primary school enrolment rates are higher than those of boys" (MDPS, 2015, p.32).

3. METHODOLOGY

The methodology of this study is explained in the following sections: the design, the population and the sampling method, the instrument, data collection, and the data analysis.

3.1. The Design of the Study

The primary aim of this study is to investigate the role of access to ICT resources at homes on students' science performance in the PISA 2015 while controlling for school- and student-related variables. Creswell (2012) stated that a correlational design is used to investigate, the degree of relationship between two or more variables. A correlational design was chosen in this study as two-level analysis between 23 variables was conducted.

3.2. The Population and the Sample

In 2015, nearly 540,000 students between the ages from 15 year olds and three months to 16 year olds and two months participated in the PISA 2015, representing 29 million students. They were in 7th grade and above and were from 72 countries (34 of them were OECD members) (OECD, 2017a).

A two-stage stratified random sampling method was used to select students to participate in the PISA 2015. In the first stage, schools were identified according to Classification of Statistical Region Units (NUTS) Level 1- considering-, training type, school type, school location, and administrative form by applying systematic sampling. After determining the number of schools whose students were PISA-eligible, a sampling interval and a random number were calculated.

After obtaining the first sample, further sample intervals were added until all of the schools had been selected. At least 150 schools were selected from each country; if a participating country had fewer than 150 schools, all schools of the schools in that country were included in the test (OECD, 2017a).

In the second step, students were chosen randomly within these schools (OECD, 2017a). Ideally, each target cluster needed to include 20 students. If the number of participating students was below 50% of the total 15-year-old students in the school, the school was not considered as participating school; however, schools in which the participation rate was 25% were included in the database and the estimates of PISA international reports. If a school's ratio was below 25%, it was not included even in the database. An overall response rate of 80% of the total of 15- year-old students in the school was required for initially selected schools (OECD, 2017a). Using this method, 5895 students from Turkey; 5741 pupils from Ireland; 6971 pupils from Peru; 12083 pupils from Qatar were selected.

Coverage index is an important concept to understand the representativeness of participated students for the countries. The Coverage index means that the extent to which the participated students covered the national desired target population. The formula is "$\frac{P}{(P+E)} \times \left(\frac{ST7b_3}{ST7b_1}\right)$," for the national desired target population. In the formula, P is "the weighted estimate of PISA-eligible non-excluded 15-year-old students and E is the weighted estimate of PISA-eligible 15-year-old students that were excluded within schools". $\frac{P}{(P+E)}$ means the proportion of the PISA-eligible 15-year-old population represented by the non-excluded PISA-eligible 15-year-old students. $\frac{ST7b_3}{STb_1}$ provides the proportion of the national population covered in each country based on national statistics "$\frac{P}{(P+E)}$" and "$\frac{ST7b_3}{STb_1}$" indicates the overall proportion of the national population covered by the non-excluded portion of the student sample" (OECD, 2017a, p.204). In 2015, the coverage percentages of participating students to the desired target population were 70% for Turkey; 97% for Ireland; 74% for Peru; 93% for Qatar (OECD, 2017a).

Information on all of the students in this study, including their gender, and grade levels are given in Table B.1 and the coverage indexes for the desired target population, total numbers of participated schools and students for all four countries are given in

Table 3.2.

Table 3.1. Detailed information of participated students' grade levels and genders.

	Boys						Girls					
	7^{th}	8^{th}	9^{th}	10^{th}	11^{th}	12^{th} grade and above	7^{th}	8^{th}	9^{th}	10^{th}	11^{th}	12^{th} grade and above
COUNTRIES	%	%	%	%	%	%	%	%	%	%	%	%
Ireland	0.0	2.2	62.8	24.1	10.9	0.0	0.0	1.4	58.2	29.0	11.3	0.0
Peru	3.0	7.5	17.9	48.7	22.9	0.0	1.9	5.6	14.0	51.7	26.8	0.0
Turkey	0.8	3.1	25.4	68.4	2.2	0.1	0.4	2.1	16.1	77.5	3.8	0.1
Qatar	0.8	3.6	18	59.3	17.6	0.6	1.0	3.4	14.5	62.1	18.4	0.6

Table 3.2. Information of participated students and coverage index for the international desired target population.

COUNTRIES	Total in national desired target population	Total of participated students	Coverage index for the national desired target population	Total number of participated schools
Ireland	59 739	5 741	0.965	167
Peru	478 229	6 971	0.744	281
Turkey	1 100 074	5 895	0.699	187
Qatar	13 850	12 083	0.934	163

3.3. The Instrument

This study used PISA 2015 test questionnaires and results which were published by OECD. Four-point Likert type was used for the answers of the variables in this study except parents' education levels, science-specific resources, classroom size, the number of computers available per student at model grade, and index teacher-related variables (OECD, 2017a). Additionally, each of the variables had different number of sub-questions. For example, while instrumental motivation variable had four items, enjoyment of science had five items to be answered. Therefore, the answer of the students for the questions were needed to be derived.

3.3.1. Student-Level Variables

Student characteristics have four indicators: students' attitudes, personal factors, factors related to classroom learning environments, and parental factors.

Student attitudes are enjoyment in science classes (JOYSCIE), instrumental motivation (INSTSCIE), science self-efficacy (SCIEEFF), epistemological beliefs (EPIST), and index of science activities (SCIEACT). Personal factors are test- anxiety (ANXTEST), achievement motivation (MOTIVAT), and subjective well-being/- a sense of belonging (BELONG), learning environments factors are students' concerns about inquiry-based science instruction (IBTEACH), disciplinary climate in science classes (DISCLISCI), and teacher-directed science instruction (TDTEACH). Parental factors are emotional support (EMOSUPS), cultural possession at home (CULTPOSS), and ICT resources (ICTRES).

3.3.1.1. Students' Attitudes Factors. Students' attitudes factors include enjoyment in science classes (JOYSCIE), instrumental motivation (INSTSCIE), science self-efficacy (SCIEEFF), epistemological beliefs (EPIST), and index of science activities (SCIEACT). For the variables, the generalized partial credit model (GPCM) (Muraki, 1992), based on item response theory (IRT) was used to create the scale scores (see part 3.5.).

3.3.1.2. Enjoyment of Science (JOYSCIE) . The variable measures students' perception of learning science in terms of how it is curios and enjoyable (OECD, 2016b). The variable consists of five items. Four-point Likert scale was used for the question including "strongly agree", "agree", "disagree", and "strongly disagree". Higher derived score for the variable means a higher enjoyment of science (OECD, 2017a).

How much do you disagree or agree with the statements about yourself below? (ST094)

- I generally have fun when I am learning <broad science> topics.
- I like reading about <broad science>.
- I am happy working on <broad science> topics.
- I enjoy acquiring new knowledge in <broad science>.
- I am interested in learning about <broad science> (OECD, 2016d, p. 154).

3.3.1.3. Instrumental Motivation (INSTSCIE). The variable is related to students' perception of school science as beneficial and useful for their careers and future works. There are four items for the variable. Four-point Likert scale was used for the question including "strongly agree", "agree", "disagree", and "strongly disagree" (OECD, 2016b). Higher derived score for the variable means a higher instrumental motivation (OECD, 2017a).

How much do you agree with the statements below? (ST113)

- Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on.
- What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on.
- Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects.
- Many things I learn in my <school science> subject(s) will help me to get a job (OECD, 2016d).

3.3.1.4. Science Self- Efficacy (SCIEEFF) . Science self-efficacy measures to what extent students cope with the problems in science and overcome the science tasks. The variable consists of eight items. Four-point Likert scale was used for the question including "I could do this easily", "I could do this with a bit of effort", "I would struggle to do this on my own", and "I couldn't do this" (OECD, 2016b). Higher derived score for the variable means a higher science self-efficacy (OECD, 2017a).

How easy do you think it would be for you to perform the following tasks on your own? (ST129)

- Recognize the science question that underlies a newspaper report on a health issue.
- Explain why earthquakes occur more frequently in some areas than in others.

- Describe the role of antibiotics in the treatment of disease.
- Identify the science question associated with the disposal of garbage.
- Predict how changes to an environment will affect the survival of certain spe-cies.
- Interpret the scientific information provided on the labeling of food items.
- Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars.
- Identify the better of two explanations for the formation of acid rain (OECD, 2016d).

3.3.1.5. Epistemological Beliefs (EPIST) . The variable is about students' way of confirming knowledge and their conviction of science evolving and altering matter. The epistemological belief variable consists of six items. Four-point Likert scale was used for the question including "strongly agree", "agree", "disagree", and "strongly disagree" (OECD, 2016b). Higher derived score for the variable means a higher epistemological belief (OECD, 2017a).

How much do you disagree or agree with the statements below? (ST131)

- A good way to know if something is true is to do an experiment.
- Ideas in <broad science> sometimes change.
- Good answers are based on evidence from many different experiments.
- It is good to try experiments more than once to make sure of your findings
- Sometimes <broad science> scientists change their minds about what is true in science.
- The ideas in <broad science> science books sometimes change (OECD, 2016d, p. 156).

3.3.1.6. Index of Science Activities (SCIEACT) . The variable measures how often students occupy themselves with science-related activities. There are nine items for the variable. Four-point Likert scale was used for the question including "very often", "regularly", "sometimes", and "never or hardly ever". The higher value means higher levels of students' science activities (OECD, 2016b). Higher derived score for the variable means a higher engagement in science activities (OECD, 2017a).

How often do you do these things? (ST146)

- Watch TV programmes about <broad science>,
- Borrow or buy books on <broad science> topics
- Visit web sites about <broad science> topics
- Read <broad science> magazines or science articles in newspapers
- Attend a <science club>
- Simulate natural phenomena in computer programs/virtual labs
- Simulate technical processes in computer programs/virtual labs
- Visit web sites of ecology organizations
- Follow news of science, environmental, or ecology organizations via blogs and microblogging (OECD, 2016d).

3.3.1.7. Students' Personal Factors. Students' personal factors consist of test- anxiety (ANXTEST), achievement motivation (MOTIVAT), and subjective well-being/- a sense of belonging (BELONG). For the variables, the generalized partial credit model (GPCM) (Muraki, 1992), based on item response theory (IRT) was used to create the scale scores (see part 3.5.).

3.3.1.8. Test Anxiety (ANXTEST) . The test-anxiety variable is about how anxiety affects students in schoolwork related issues. There are five items for the variable. Four-point Likert scale was used for the question including "strongly disagree", "disagree", "agrees", and "strongly agree" (OECD, 2016b). Higher derived score for the variable means a higher test anxiety (OECD, 2017a).

To what extent do you disagree or agree with the following statements about yourself? (ST118)

- I often worry that it will be difficult for me taking a test.
- I worry that I will get poor <grades> at school.
- Even if I am well prepared for a test, I feel very anxious.
- I get very tense when I study for a test.
- I get nervous when I don't know how to solve a task at school (OECD, 2016d).

3.3.1.9. Achievement Motivation (MOTIVAT) . The achievement motivation is about students' motivation to achieve in their lives including school. There are five items for the variable. Four-point Likert scale was used for the question including "strongly disagree", "disagree", "agree", and "strongly agree" (OECD, 2016b). Higher derived score for the variable means a higher achievement motivation (OECD, 2017).

To what extent do you disagree or agree with the following statements about yourself? (ST119)

- I want top <grades> in most or all of my courses.
- I want to be able to select from among the best opportunities available when I graduate.
- I want to be the best, whatever I do.
- I see myself as an ambitious person.
- I want to be one of the best students in my class (OECD, 2016d, p. 147).

3.3.1.10. Sense of Belonging to school; Subjective well-being (BELONG) . The variable is about students' life evaluations and affective states during school times. The sense of belonging to the school variable includes six items. Four-point Likert scale was used for the question including "strongly agree", "agree", "disagree", and "strongly disagree" (OECD, 2016b). Higher derived score for the variable means a higher sense of belonging to school (OECD, 2017a).

Thinking about your school: to what extent do you agree with the following statements? (ST034)

- I feel like an outsider (or left out of things) at school.
- I make friends easily at school
- I feel like I belong at school.
- I feel awkward and out of place in my school.
- Other students seem to like me.
- I feel lonely at school (OECD, 2016d, p.148).

3.3.1.11. Students' Parental Factors. : Parental factors are emotional support (EMOSUPS), highest parental education in years (PARED), cultural possession at home (CULTPOSS), and ICT resources (ICTRES). For the variables except highest parental education in years, the generalized partial credit model (GPCM) (Muraki, 1992), based on item response theory (IRT) was used to create the scale scores (see part 3.5.). For the highest parental education in years (PARED), the highest educational level of parents (HISCED) was transformed PARED, by calculating the estimated number of years of schooling.

3.3.1.12. Highest Parental Education in Years (PARED). The highest education in years variable is measured education levels of mothers and fathers of students as years. The variable consists of four questions and ten sub educational levels.

What is the <highest level of schooling> completed by your mother? ST005

- She did not complete ISCED level 1, ISCED level 1(primary education), ISCED level 2 (lower secondary), ISCED level 3B, 3C (vocational/prevocational upper secondary), ISCED level 3A (general upper secondary).

Does your mother have any of the following qualifications? ST006

- ISCED level 4 (non-tertiary post-secondary), ISCED level 5B (vocational tertiary), ISCED 5A (theoretically oriented tertiary), ISCED level 6 (postgraduate)

What is the <highest level of schooling> completed by your father? ST007

- He did not complete ISCED level 1, ISCED level 1(primary education), ISCED level 2 (lower secondary), ISCED level 3B, 3C (vocational/prevocational upper secondary), ISCED level 3A (general upper secondary)

Does your father have any of the following qualifications? ST008

- ISCED level 4 (non-tertiary post-secondary), ISCED level 5B (vocational tertiary), ISCED 5A (theoretically oriented tertiary), ISCED level 6 (postgraduate) (OECD, 2016d).

3.3.1.13. Parents Emotional Support (EMOSUPS). The parents' emotional support variable is about how much parents support their children emotionally in their school. The variable includes four items. Four-point Likert scale was used for the question including "strongly agree", "agree?, "disagree", and "strongly disagree" (OECD, 2016b). Higher derived score for the variable means a higher parent emotional support (OECD, 2017a).

Thinking about the <this academic year>: to what extent do you agree or disagree with the following statements? (ST123)

- My parents are interested in my school activities.
- My parents support my educational efforts and achievements
- My parents support me when I am facing difficulties at school.
- My parents encourage me to be confident (OECD, 2016d, p. 145).

3.3.1.14. Cultural Possessions at Home (CULTPOSS) . The cultural possession at home variable is accepted as an indicator of household possessions at home. Two questions were used for the variable (ST011/ST012). One of the questions is included yes/no answers, and the other is included "none", "one", "two", or "three or more" options

(OECD, 2016b). Higher derived score for the variable means a higher cultural possession at home (OECD, 2017a).

- Classic literature (e.g. <Shakespeare¿)
- Books of poetry
- Works of art (e.g. paintings)
- Books on art, music, or design
- Musical instruments (e.g. guitar, piano) (OECD, 2016d, pp. 143-144).

3.3.1.15. ICT Resources (ICTRES)). The variable is also accepted as an indicator of household possessions at home of students. Two questions were used for the variable (ST011/ST012. One of the questions is included yes/no answers, and the other is included "none", "one", "two", or "three or more" options. The questions are about their access to ICT resources at their homes (OECD, 2016b). Higher derived score for the variable means a higher ICT resources at home (OECD, 2017a).

- Educational software
- A link to the Internet
- <Cell phones> with Internet access (e.g. smartphones)
- Computers (desktop computer, portable laptop, or notebook)
- <Tablet computers¿ (e.g. <iPad® >, <BlackBerry® PlayBookTM¿)
- E-book readers (e.g. <KindleTM>, <Kobo>, <Bookeen¿) (OECD, 2016d).

3.3.1.16. Classroom Learning Environment. Classroom learning environment factors include students' concerns about inquiry-based science instruction (IBTECH), disciplinary climate in science classes (DISCLISCI), and teacher-directed science instruction (TDTEACH). For the variables except highest parental education in years, the generalized partial credit model (GPCM) (Muraki, 1992), based on item response theory (IRT) was used to create the scale scores (see part 3.5.).

3.3.1.17. Inquiry-based Instruction (IBTEACH) . Inquiry-based science instruction variable is about students' active participation, thinking, and data-driven reasoning in their science classes. There are nine items for the variable. Four-point Likert scale was used for the question including "in all lessons", "in most lessons", "in some lessons", and "never or hardly ever". Higher derived score for the variable means a higher inquiry based instruction in science classes (OECD, 2017a).

When learning <school science> topics at school, how often do the following activities occur? (ST098)

- Students are given opportunities to explain their ideas.
- Students spend time in the laboratory doing practical experiments.
- Students are required to argue about science questions.
- Students are asked to draw conclusions from an experiment they have conducted.
- The teacher explains how a <school science> idea can be applied to a number of different phenomena (e.g. the movement of objects, substances with similar properties)
- Students are allowed to design their own experiments.
- There is a class debate about investigations.
- The teacher clearly explains the relevance of <broad science> concepts to our lives.
- Students are asked to do an investigation to test ideas (OECD, 2016d, p. 152).

3.3.1.18. Disciplinary Climate in Science Classes (DISCLISCI) . The disciplinary climate in the science class variable is about "the structure and efficacy of classroom environment" (OECD, 2017a, p.114). The variable consists of five items. Four-point Likert scale was used for the question including "every lesson", "most lessons?, "some lessons", and "never or hardly ever". Higher derived score for the variable means a higher disciplinary climate in science classes (OECD, 2017a).

To what extent are you interested in the following <broad science> topics? (ST097)

- Students don't listen to what the teacher says.
- There is noise and disorder.
- The teacher has to wait a long time for students to quiet down.
- Students cannot work well.
- Students don't start working for a long time after the lesson begins (OECD, 2016d, p. 151).

3.3.1.19. Teacher-Directed Science Instruction (TDTEACH). Teacher-directed science instruction is about teachers' activities and to gather information about classroom learning environment during the science lessons. Four-point Likert scale was used for the question including "never or almost never", "some lessons", "many lessons", and "every lesson or almost every lesson". Higher derived score for the variable means a higher teacher-directed science instruction (OECD, 2017a).

How often do these things happen in your lessons for this <school science> course? (ST103)

- The teacher explains scientific ideas
- A whole class discussion takes place with the teacher.
- The teacher discusses our questions.
- The teacher demonstrates an idea (OECD, 2016d, p. 153).

3.3.2. School-Level Variables

School level variables also have two sub-areas: physical factors, and teacher-related factors.

Physical factors are class size (CLSIZE), the number of computers available per student at modal grade (RATCMP1), shortage of educational materials (EDUSHORT), shortage of educational staff (STAFFSHORT), and the index of science-specific resources (SCIERES). Teacher-related factors are the index of the proportion of science teachers by all teachers (PROSTAT), the index of the proportion of fully certificated science teachers (PROSTCE), the index of the proportion of science teachers with an International Standard Classification of Education (ISCED) level 5A (Theoretically oriented tertiary) (PROSTMAS) and a major in science.

3.3.2.1. Physical Factors. Physical factors include class size (CLSIZE), the number of computers available per student at modal grade (RATCMP1), shortage of educational material (EDUSHORT), shortage of educational staff (STAFFSHORT), and the index of science-specific resources (SCIERES). For the variables except class size, the numbers of computers available per student at model grade, and the index of science-specific resources, the generalized partial credit model (GPCM) (Muraki, 1992), based on item response theory (IRT) was used to create the scale scores (see part 3.5.). "The index of availability of computers (RATCMP1) is the ratio of computers available to 15-year olds for educational purposes to the total number of students in the modal grade for 15-year olds" (OECD, 2017, p.321).

3.3.2.2. Classroom Size (CLSIZE) . The variable is created from one of the nine options from "15 students or fewer" to "more than 50 students".

What is the average size of <test language> classes in <national modal grade for 15-year-olds> in your school? (SC003)

- 15 students or fewer,
- 16-20 students,
- 21-25 students,
- 26-30 students,
- 31-35 students,

- 36-40 students,
- 41-45 students,
- 46-50 students,
- More than 50 students (OECD, 2016d, p. 130).

3.3.2.3. Shortage of Educational Material (EDUSHORT) . The variable is about the perceptions of school principals about factors that could obstruct the quality of instructions related to educational materials in their schools. There are four items for the variable. Four-point Likert scale was used for the question including “not at all”, “very little”, “to some extent”, to “a lot”. Higher derived score for the variable means a higher shortage of educational materials (OECD, 2017a).

Is your school’s capacity to provide instruction hindered by any of the following issues? (SC017)

- A lack of educational materials (e.g. textbooks, IT equipment, library or laboratory material).
- Inadequate or poor-quality educational material (e.g. textbooks, IT equipment, library or laboratory material).
- A lack of physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems).
- Inadequate or poor-quality physical infrastructure (e.g. building, grounds, heating/cooling, lighting and acoustic systems) (OECD, 2016d, p. 134).

3.3.2.4. Shortage of Educational Staff (STAFFSHORT) . The variable is about the perceptions of school principals about factors that could obstruct the quality of instructions related to teaching staff in their schools. There are four items for the variable. Four-point Likert scale was used for the question including “not at all”, “very little?, “to some extent”, to “a lot”. Higher derived score for the variable means a higher shortage of educational staff (OECD, 2017a).

Is your school's capacity to provide instruction hindered by any of the following issues? (SC018)

- A lack of teaching staff.
- Inadequate or poorly qualified teaching staff.
- A lack of assisting staff.
- Inadequate or poorly qualified assisting staff (OECD, 2016d, p. 131).

3.3.2.5. Index of Computer Availability (RATCMP1) . RATCMP1 is the ratio of computers available to 15-year olds for educational purposes to the total number of students in the modal grade for 15-year olds (SC004). Higher score for the variable means higher number of computers available per student at model grade.

- At your school, what is the total number of students in the <national modal grade for 15-year-olds>?
- Approximately, how many computers are available for these students for educational purposes?
- Approximately, how many of these computers are connected to the Internet/World Wide Web?
- Approximately, how many of these computers are portable (e.g. laptop, tablet)?
- Approximately how many interactive whiteboards are available in the school altogether?
- Approximately how many data projectors are available in the school altogether?
- Approximately how many computers with internet connection are available for teachers in your school? (OECD, 2016d, p. 131).

3.3.2.6. Science Specific Resources (SCIERES) . The variable is about science-specific sources in the schools. The answer collected from principals by adding their responses for eight items. The question is included yes/no answers. Higher score for the variable means higher science specific resources (OECD, 2017a).

Which of the following are true for the science department of your school? (YES/NO) (SC059)

- Compared to other departments, our schools' <school science department> is well equipped.
- If we ever have some extra funding, a big share goes into improvement of our <school science> teaching
- <School science> teachers are among our best-educated staff members.
- Compared to similar schools, we have a well-equipped laboratory.
- The material for hands-on activities in <school science> is in good shape.
- We have enough laboratory material that all courses can regularly use it.
- We have extra laboratory staff that helps support <school science> teaching.
- Our school spends extra money on up to date <school science> equipment OECD, 2016d, p. 131).

3.3.2.7. Teacher-related Factors. Teacher-related factors involve the index of the proportion science teachers by all teachers (PROSTAT), the index of the proportion of fully certificated science teachers (PROSTCE), the index of the proportion of science teachers with an International Standard Classification of Education (ISCED) level 5A (Theoretically oriented tertiary) (PROSTMAS) and a major in science. The IRT scaling was not used for the variables because the variables are in proportions.

3.3.2.8. Science Teachers (PROSTAT). It was computed by dividing the number of science teachers by the total number of teachers. Higher score for the variable means a higher number of science teachers at a school (OECD, 2017a).

How many of the following teachers are on the staff of your school? /How many of the following teachers are on the <school science> staff of your school? (SC018/SC019)

- Teachers <fully certified> by <the appropriate authority>
- <School science> teachers <fully certified> by <the appropriate authority>

(OECD, 2016d).

3.3.2.9. Science Teachers Fully Certified (PROSTCE) . It was computed by dividing the number of fully certified science teachers by the total number of teachers. Higher score for the variable means a higher number of fully certified science teacher at a school (OECD, 2017a).

How many of the following teachers are on the staff of your school? /How many of the following teachers are on the ¡school science¿ staff of your school? (SC018/SC019)

- Teachers <fully certified> by <the appropriate authority>
- <School science> teachers <fully certified> by <the appropriate authority> (OECD, 2016d).

3.3.2.10. Science Teachers with ISCED level 5A and a Major in Science (PROSTMAS). It was calculated by dividing the number of these teachers by the total number of science teachers. Higher score for the variable means a higher number of ISCED level 5A and a major in science teachers (OECD, 2017a).

How many of the following teachers are on the staff of your school? /How many of the following teachers are on the <school science> staff of your school? (SC018/SC019)

- Teachers with an <ISCED Level 5A Bachelor's degree> qualification
- Teachers with an <ISCED Level 5A Master's degree> qualification
- Teachers with an <ISCED Level 6> qualification
- <School science> teachers with an <ISCED Level 5A or higher> qualification <with a major> in <school science> (OECD, 2016d, p. 135).

3.4. Ethical Review Issues and Data Translation Protocol

The ethical review board could not be found. The Secretary-General of the OECD was shown as responsible of publishing the technical report (OECD, 2017a).

The PISA tests are developed both in the English and French languages. Just the financial literacy and the operational manuals are in the English language. For the French version of the assessment, the double translation and reconciliation process were used. A French domain expert checked the translated document the terminology and a native professional French proof-reader checked the translated document for the language use. By using double translation design from two source languages, the assessment was translated into participated countries' languages. For the double translation design, one independent translator is responsible for the use of English source of the document and the other is responsible for the French version of the document (OECD, 2017a).

PISA Translation and Adaption Guidelines were prepared for the national teams. National project managers are responsible for applying and saving the assessments in a sampling for the agreement (OECD, 2017a).

The open language tool (OLT) software on XLIFF (tagged XLM Localization Interchange File Format) files was used for validation and translation of computer-based units (OECD, 2017a).

Ireland used Irish version, Peru used Spanish version, Turkey used Turkish version, and Qatar used Arabic version of the test (OECD, 2017a).

3.5. Scale Scores

The generalized partial credit model (GPCM) (Muraki, 1992), based on item response theory (IRT) was used to create the scale scores for the scale questionnaires.

The formula for the model is;

$$P\left(X_{ji}=k|\theta_j,\beta_i,\alpha_i,d_i\right)=\frac{\exp\left(\sum_{r=0}^{k}\alpha_i\left(\theta_j-\left(\beta_i+d_{ir}\right)\right)\right)}{\sum_{u=0}^{m_i}\alpha_i\exp\left(\sum_{r=0}^{u}\alpha_i\left(\theta_j-\left(\beta_i+d_{ir}\right)\right)\right)} \tag{3.1}$$

The average OECD student score would have an index value of zero and about two-thirds of the OECD student population would be between the values of -1 and 1' (OECD, 2017a, p.293), because "weighted likelihood estimates" (WLE; Warm, 1989) were used as individual participant scores and transformed to an international metric with an OECD mean of zero and an OECD standard deviation of one (OECD, 2017a, p.291).

3.6. Reliability Coefficients of the Scale Scores (Cronbach's Alpha Coefficients)

Cronbach's Alpha values are used to estimate the internal consistency of the scales. This term means how well the items in a questionnaire are consistent with each other (Rakovshik, 2020). In short, Cronbach's Alpha coefficients indicate the reliability of the items in the test. While 0.7 is an acceptable score for the value, the value which is above 0.8 is seen as good, and 0.9 as excellent (Field, 2018; OECD, 2017a). Cronbach's alpha coefficients for the variables and each country in the research were taken from the technical report of the PISA 2015 (OECD, 2017a) and given in Table 3.6.

Table 3.3. Scale reliabilities (cronbach's alpha coefficients) for each variable and country.

	IRELAND	**PERU**	**TURKEY**	**QATAR**
Level-1				
Disciplinary climate in science class	0.91	0.84	0.89	0.90
Inquiry based science instruction	0.84	0.88	0.89	0.9
Teacher directed science instruction	0.82	0.83	0.80	0.882
Enjoyment of science	0.95	0.91	0.94	0.94
Instrumental motivation	0.93	0.88	0.90	0.89
Science self-efficacy	0.87	0.85	0.89	0.90
Epistemological beliefs	0.82	0.88	0.92	0.90

Table 3.3. Scale reliabilities (cronbach's alpha coefficients) for each variable and country (cont.).

	IRELAND	PERU	TURKEY	QATAR
Index science activities	0.89	0.91	0.94	0.93
Sense of belonging to school	0.86	0.77	0.85	0.78
Test-Anxiety	0.82	0.65	0.82	0.78
Achievement motivation	0.81	0.7	0.84	0.87
Parents' emotional support	0.88	0.82	0.86	0.87
Highest parental education	0.80	0.82	0.79	0.78
Cultural possession at home	0.58	0.51	0.64	0.57
ICT resources	0.46	0.73	0.67	0.62
Level-2				
Shortage of educational materials	0.87	0.89	0.90	0.88
Shortage of educational staff	0.72	0.77	0.80	0.86

All coefficients except cultural possession at home for each country and ICT resources for Ireland and Qatar are above 0.7. Students' science attitudinal factors such as enjoyment of science, instrumental motivation, and science self-efficacy variables have the highest reliability values which are above 0.9 for all four countries. For Peru, the reliability values of Cultural possession at home variable is 0.5, and for Ireland, Turkey, and Qatar are 0.6. The reliability values for ICT resources variable for Ireland and Qatar are 0.5 and 0.6 respectively. An explanation for the low reliability coefficient values of ICT resources and Cultural possession at home could not be found in the Technical report (OECD, 2017a).

3.7. Data Analysis

All of the data were taken from the OECD's official website. The OECD carries out the assessment and is responsible for all processes namely implementation, data collection, and the publication of results.

For descriptive analysis, the International Association for the Evaluation of Educational Achievement (IEA) International Database analyzer (IDB Analyzer) was used because the program takes into account student weights for the analysis. Descriptive statistics included mean, standard error (SE), and standard deviation (SD) values for the variables.

To answer the research questions, two-level regression analyses were conducted using Mplus. Mplus is a statistical modeling program that provides for the analysis of both cross-sectional and longitudinal data, single-level and multilevel data, data that come from different populations with either observed or unobserved heterogeneity, and data that contain missing values (Muthén & Muthén, 2010). Additionally, Mplus can take into account plausible values and sample weights.

In this section, sampling weights, plausible values, descriptive statistics, two-level regression, intraclass correlation, and assumptions are explained in detail.

3.7.1. Sampling Weights

If random sampling is not used and the sampling frame does not represent the whole population, the results can be biased. To prevent the bias and establish representativeness of the population, sample weights should be considered (Arıkan, Özer, Şeker, & Ertaş, 2020; OECD, 2009; Rutkowski, Gonzalez, Joncas, & von Davier, 2010). Sampling weights are statistical values for supplying representativeness of population by sample. Based on this perspective, because two-stage clustered sampling was used for the PISA 2015, weighting the samples is required. In this study, student weights were taken into account for all analyses.

3.7.2. Plausible Values

In order to minimize measurement error for both at the individual level and generalization of the results to the population, plausible values are used (Laukaityte & Wiberg, 2017; OECD, 2009). On the other hand, because the rotated booklet design is used in PISA test to lighten the load of students, students' performances are given as plausible values (Arıkan *et al.*, 2020). There are 10 plausible values in the PISA

2015 for each science, mathematics, and reading domain. For each student, these are calculated by using the population model. The model requires the combination of the item parameter estimates from the item calibration stage and the estimates of regression weights (Γ) and a residual variance-covariance (Σ) from the latent regression model (OECD, 2017a). In this study, science plausible values (PVs) were taken into account for the analyses.

3.7.3. Descriptive Statistics

Descriptive statistics included mean, standard error (SE), and standard deviation (SD) values for the variables. The IEA International Database analyzer (IDB Analyzer) was used for the analyses because the program considers student weights for the analysis.

3.7.4. Assumptions of Two-Level Regression

Assumptions of multiple two-level regression consist of sample size, multicollinearity, normality, linearity, and homoscedasticity (Field, 2009; Keith, 2014; Pallant, 2007; Tabachnick & Fidel, 2007).

3.7.4.1. Sample Size. Having sufficient number of participants is crucial for the reliability of an analysis (Field, 2009). There are two perspectives for calculating least number of required sample size. One of them is given by Tabahnick & Fidell (2007) as "N > 50 + 8m" (p.123) (m: number of independent variables, N: required sample size). The other one is given by Keith (2014) as "N >10m or 20m" (p.203) (m number of independent variables, N: required sample size). This means that the number of samples should be at the least ten times the number of independent variables.

3.7.4.2. Linearity. There should be a linear relationship between dependent and independent variables. If this assumption is not met, the analysis model of a research could not be valid even though other assumptions are true (Field, 2018; Keith, 2014).

This assumption can be checked by using a plot of regression standardized residuals (ZRESID) and regression standardized predicted value (ZPRED) (Field, 2009). There should be a linear relationship between them. If there is a curvilinear relationship between them, the linear model would not be appropriate (Field, 2018).

3.7.4.3. Independence of Residuals. The errors for each person in the sample should be independent from others (Keith, 2014). There are two ways of checking the assumption. One of them is the Durbin-Watson test. The value for the result of the test can change between zero to four. The value of two is the expected result meaning that residuals are uncorrelated. The result, which is greater than two means a negative correlation, but the result which is smaller than two means a positive correlation. On the other hand, the acceptable values can vary depending on research, because the Durbin-Watson test subjects to the number of variables and dataset in the analysis. The second one is drawing a plot of standardized residuals (ZRESID) and standardized predicted values (ZPRED). Random patterns of dots meet the independence of the errors on the graph (Field, 2018). If there are not random patterns for residuals, the assumption is violated. 3.7.4.4. Homoscedasticity: The variance of the errors around the regression line should be fairly constant for all predicted scores. Scatterplot of residuals and predicted values is useful way of checking the assumption. Additionally, checking a ratio of high to low variance is less than 10 or not. If the ratio is less than 10, the assumption can be accepted as satisfied (Keith, 2014). 3.7.4.5. Normality: The errors should be normally distributed. If the sample size is small, the violation of the assumption is an important matter. There are two main ways of checking the assumption. One of them is the superimposed normal curve and the other is the q-q plot. If the normality is supplied, the line of the expected and actual residuals should be very close (Keith, 2014).

3.7.4.4. Multicollinearity (Collinearity). Multicollinearity means highly correlated independent variables (r= .9). One of the ways of checking the assumption is that considering two values which are tolerance and the variance inflation factor (VIF). The tolerance range is from 0 (no independence) to 1 (complete independence). VIF should be up to 10. Multicollinearity exists when a value is small for tolerance and large for

VIF. The other is to check correlational values for the variable. There should not be multicollinearity for multiple regression.

3.7.5. Two-Level Regression

In the simple linear model, the relationship between students' performance and an independent variable are investigated in student level (OECD, 2009). However, the two-level regression can account for variance when the predictor variables are at different levels, for example, at the student level (a lower level) and the school level (a higher level) (Raudenbush & Bryk, 2002; Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2004; Woltman, Feldstain, MacKay, & Rocchi, 2012). The hierarchical linear model (Bryk, & Raudenbush, 1992) also called multi-level models (Goldstein, 1995) accepts that some variables are embedded within other variables (Field, 2009). In the PISA tests, results are gathered at many levels such as students and schools. Thus, the variation in the results can be caused by not only students but also schools. In this study, two-level datasets which are students and schools are used based on PISA 2015 results. Students are clustered within schools. (OECD, 2009). Therefore, students are at the first level of the analysis, and schools are at the second level of the analysis. The general formula for the two-level regression model and its' adapted version to this study are given below, respectively (3.2 & 3.3).

Level - 1 Model

$$Y_{ij} = b_{0j} + b_{1j}X_{ij} + \varepsilon_{ij} \tag{3.2}$$

Level - 2 Model

$$\begin{aligned} lb_{0j} &= y_{00} + y_{01}W_j + u_{0j} \\ b_{1j} &= y_{10} + u_{1j} \end{aligned} \tag{3.3}$$

In the formula, Y_{ij} is science performance of student i in school j; b_{0j} is the random intercept for school j; b_{1j} is the slope for the variable X; X_{ij} is level 1 variables for student i in school j; ε_{ij} is the error; y_{00} is the fixed intercept; y_{01} is the slope between the dependent variable and Level 2 predictor; w_j is level 2 variables; u_{0j} is the school departure from the overall intercept; y_{10} is the slope between dependent variable and level 1 variable; u_{1j} is the error for the slope. The error means that the difference between predicted by the line and obtained scores of the students in the sample. Additionally, in this study, a random intercept model is used because the intercepts can change depending on the contexts or samples. S_o, the formula which included the random intercept model is given above (Field, 2009; OECD, 2017a).

For this study, the formula takes the form of
Level - 1 Model

$$\begin{aligned} Y_{ij} &= b_{0j+}b_{1j} * (JOYSCIE) + b_{2j} * (INSTSCIE) + b_{3j} * (SCIEEFF) \\ &+b_{4j} * (EPIST) + b_{5j} * (SCIEACT) + b_{6j} * (ANXTEST) \\ &+b_{7j} * (MOTIVAT) + b_{8j} * (BELONG) + b_{9j} * (EMOSUPS) \\ &+b_{10j} * (PARED) + b_{11j} * (CULTPOSS) + b_{12j} * (ICTRES) \\ &+b_{13j} * (DISCLISCI) + b_{14j} * (IBTEACH) + b_{15j} * (TDTEACH) + \varepsilon_{ij} \end{aligned} \tag{3.4}$$

Level - 2 Model

$$\begin{aligned} &b_{0j} = y_{00} + y_{01} * (CLSIZE) + y_{02} * (RATCMP1) + \\ &y_{03} * (EDUSHORT) + y_{04} * (STAFFSHORT) \\ &+y_{05} * (PROSTAT) + y_{06} * (PROSTCE) + y_{07} * (PROSTMAS) \\ &+y_{08} (SCIERES) + u_{0j} b_{1j} = y_{10} + u_{1j} \end{aligned} \tag{3.5}$$

The results of analyzes are given based on three nested models. The first model is a one-level hierarchical linear model used for the student-level variables. The second model is a two-level regression model used to address the student- and school-levels variables. The variable for ICT resources are not included in either of these two models. The third model involves a two-level regression and included the variable for ICT resources additionally in order to observe the relationship between ICT resources and science performance.

Negative values on the tables mean that "students responded the question less positively than the average student across OECD countries" and positive values on the tables mean that "students responded the question more positively than the average student in OECD countries" (OECD, 2017a, p.293).

3.7.5.1. Intraclass Correlation (ICC). Intraclass correlation is used for measuring the effect of levels or clusters on the outcome in the analyses. For a two-level model, the concept presents the percentage of total variability stemming from the second level. This means that if ICC is small in a study, the effects of second level variables in this study are small. Controversially, if ICC is large in a study, the effects of second level variables in this study are large (Field, 2018). In this study, ICC represents how much total variance is explained by the school variables (Field, 2009), because students are nested within schools, and schools are accepted as a cluster. ICC is important to decide whether two-level regression is necessary or not. The formula for the Intraclass correlation is given below (3.4)

$$\rho = \frac{\sigma^2_{between-school}}{\sigma^2_{between-school} + \sigma^2_{within-school}} = \frac{\tau_0^2}{\tau_0^2 + \sigma^2} \quad (3.6)$$

3.7.6. Handling Missing Values

There are different methods for handling missing values such as multiple imputation and list wise deletion. However, this is a controversial issue and each of the methods has strengths and weakness (Howell, 2008).

Multiple imputation (MI) defined by Rubin (1988) as each missing value is interchanged two or more plausible imputed values. There are different techniques for multiple imputation and the most popular one is the Markov Chain Monte Carlo (MCMC) algorithm (Allison, 2001; Howell, 2008). One of the disadvantages of multiple imputation is that it creates different values each time when a person uses it. On the other hand, there are different ways for MI and the most suitable way for a study should be determined (Allison, 2001). Finally, for the same dataset, different researchers can have different results when the methods are used (Soley- Bori, 2013).

Listwise deletion is also known as case wise deletion or available case analysis and means that deletion of any case which involves one or more missing observations (Howell, 2008). One of the downsides of listwise deletions is that some useable datasets could be deleted because of just one missing variable. Data should be Missing Completely at Random (MCAR) to apply list wise deletion (Allision, 2001; Carter, 2006; Goldstein, 2017; Soley-Bari, 2013). MCAR means that missingness does not interconnect any other variables or value of the variable (Allison, 2001; Carter, 2006; Soley-Bari, 2013).

Advantage of the both two methods is that they are suitable virtually for all datasets or models (Allision, 2001; Rubin, 1988). Additionally, Allision (2001) stated listwise deletion as an "honest" way for dealing with missing values. Another benefit of the listwise deletion is all analyses in a research can be conducted with the same cases (Carter, 2006).

In this study, list wise deletion was selected for handling missing values. There is different coding for the missing values of different variables in the dataset of this study. For example, while the missing values for the variable of RATCMP 1 are coded as from 995 to 999, the variable of SCIERES is coded from 95 to 99. Therefore, missing values for all variables were recoded as 999999. Then, recoded missing values were list wise deleted from datasets.

4. RESULTS

The aim of this study was to investigate the relationship between access to ICT resources and other correlates and, science performance of 15-year-old students in PISA 2015. In this study, ICT resources is hypothesized as a possible explanation for the low science performance in PISA 2015 because the assessment was computer-based for the first time.

4.1. Descriptive Analysis of the Variables

IDB Analyzer was used for descriptive statistics including mean, standard error (SE), and standard deviation (SD). Parents emotional support and ICT resources variables' mean scores for Peru and Turkey are below zero, which means that students in the countries answered the questions less positively than the average students across OECD countries as seen in the Table 4.1. On the other hand, Turkey has the lowest mean score for the number of available computers per student at schools and the largest classroom size as seen in the Table 4.1. While classroom sizes for Ireland, Peru, and Qatar are below 30 students, the number is 47 for Turkey.

Table 4.1. Descriptive statistics (weighted mean, standard error (SE) and standard deviation (SD) values).

	IRELAND			**PERU**			**TURKEY**			**QATAR**		
	Mean	**SE**	**SD**	**Mean**	**SE**	**SD**	**Mean**	**SE**	**SD**	**Mean**	**SE**	**SD**
Level-1												
Disciplinary climate in science class	0.09	0.02	1.03	0.14	0.01	0.86	-0.12	0.02	0.96	-0.07	0.01	1.02
Inquiry based science instruction	0.01	0.02	0.79	0.69	0.02	0.96	0.32	0.02	1.17	0.47	0.01	1.13
Teacher directed science instruction	-0.02	0.02	0.93	-0.02	0.02	0.93	-0.04	0.02	0.98	0.18	0.01	1.10
Enjoyment of science	0.2	0.02	1.1	0.4	0.01	0.93	0.15	0.02	1.17	0.36	0.01	1.09
Instrumental motivation	0.36	0.02	0.98	0.51	0.01	0.77	0.38	0.01	0.92	0.52	0.01	0.89

Table 4.1. Descriptive statistics (weighted mean, standard error (SE) and standard deviation (SD) values) (cont.).

	IRELAND			PERU			TURKEY			QATAR		
	Mean	**SE**	**SD**	**Mean**	**SE**	**SD**	**Mean**	**SE**	**SD**	**Mean**	**SE**	**SD**
Science self-efficacy	0.06	0.02	1.2	0.34	0.02	1.01	0.35	0.02	1.32	0.36	0.02	1.34
Epistemological beliefs	0.21	0.01	0.85	-0.16	0.01	0.92	-0.17	0.03	1.18	-0.10	0.01	1.03
Index science activities	-0.37	0.02	1.07	0.70	0.02	0.95	0.68	0.02	1.15	0.79	0.01	1.16
Sense of belonging to school	-0.01	0.01	0.94	-0.22	0.01	0.80	-0.44	0.01	1.11	-0.10	0.01	0.99
Test-Anxiety	0.14	0.02	0.89	0.13	0.01	0.71	0.31	0.02	1.05	0.22	0.01	0.97
Achievement motivation	0.39	0.01	0.94	0.34	0.01	0.77	0.62	0.02	1.03	0.77	0.01	1.04
Parents' emotional support	0.24	0.01	0.94	-0.24	0.01	0.95	-0.26	0.15	1.08	0.01	0.01	1.04
Highest parental education	13.99	0.05	2.17	12.8	0.08	3.36	9.73	0.15	4.50	14.67	0.02	2.60
Cultural possession at home	0.01	0.02	1.01	0.03	0.20	0.76	-0.25	0.02	0.87	-0.10	0.01	0.89
ICT resources	0.17	0.02	0.91	-1.62	0.03	1.17	-1.18	0.03	0.97	0.62	0.01	1.27
Level-2												
Classroom size	0 24.56	0.26	3.72	27.69	0.44	8.59	47.15	0.96	10.51	29.34	0.02	8.94
Numbers of available computers per student	0.66	0.03	0.44	0.41	0.02	0.44	0.16	0.02	0.24	0.71	0.00	0.83
Shortage of educational materials	0.25	0.09	1.20	0.51	0.08	1.37	0.12	0.10	1.26	-0.65	0.00	0.83
Shortage of educational staff	0.12	0.07	0.93	0.34	0.07	1.12	0.53	0.08	1.11	0-.71	0.00	1.06
Index science teachers	0.14	0	0.04	0.18	0.01	0.14	0.14	0.00	0.06	0.27	0.00	0.24
Index science teachers fully certified	0.97	0.01	0.11	0.90	0.01	0.24	0.45	0.04	0.48	0.77	0.00	0.41
Index science teachers with ISCED level 5A and a major in science	0.91	0.02	0.18	0.21	0.02	0.33	0.78	0.03	0.39	0.3	0.00	0.32
Science specific resources	5.69	0.12	1.60	2.79	0.13	2.07	2.60	0.19	2.36	7.00	0.00	1.47
(SE: Standard Error, SD: Standard Deviation)												

4.2. Testing the Assumptions

4.2.1. Sample Size

The sample size should be at least ten times the number of independent variables (Keith, 2014). In the research, there are 23 independent variables, therefore the number of participants should be at least 240. All four countries in the research have a much bigger number of students. Therefore, this assumption was not violated.

4.2.2. Linearity, Homoscedasticity, and Independence of Errors

Histogram of ZPRED and ZRESID is one way for checking linearity, independence of errors, and homoscedasticity assumptions (Field, 2009). The histograms for all four countries were given below. As the distribution of ZPRED and ZRESID is not violated, all three assumptions were met.

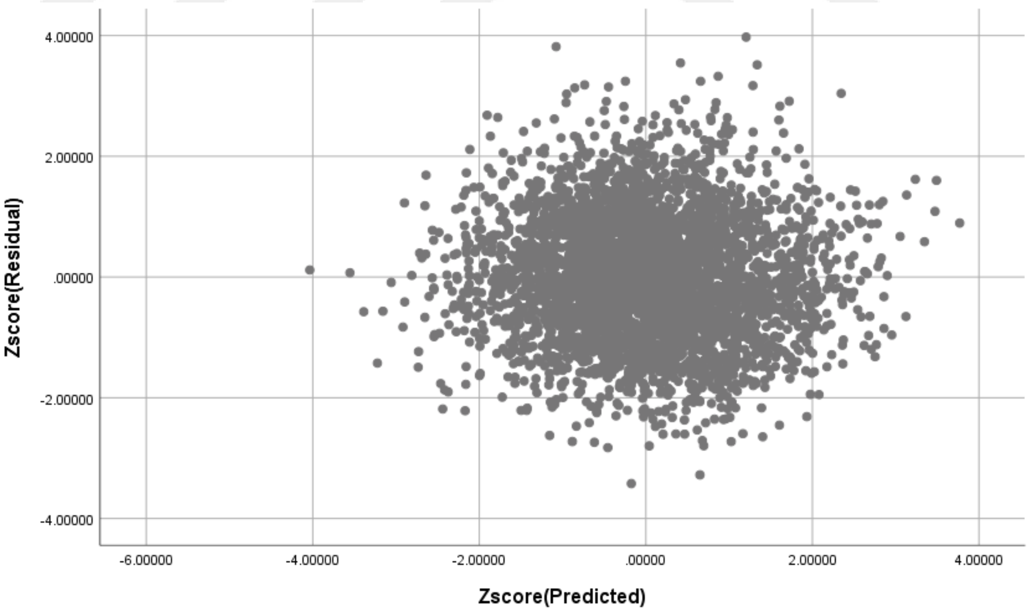

Figure 4.1. ZPRED and ZRESID histogram for Ireland.

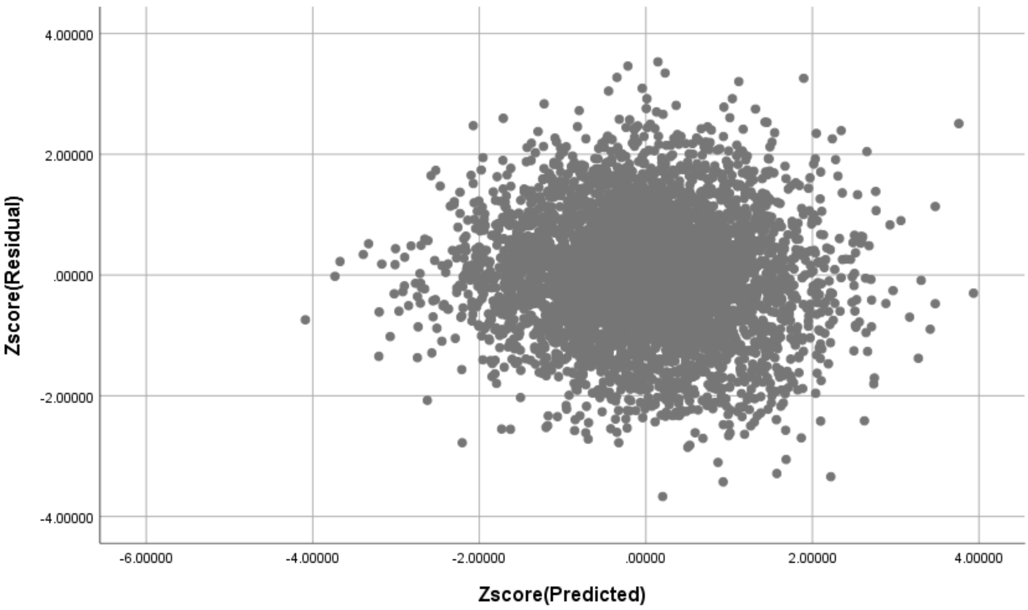

Figure 4.2. ZPRED and ZRESID histogram for Peru.

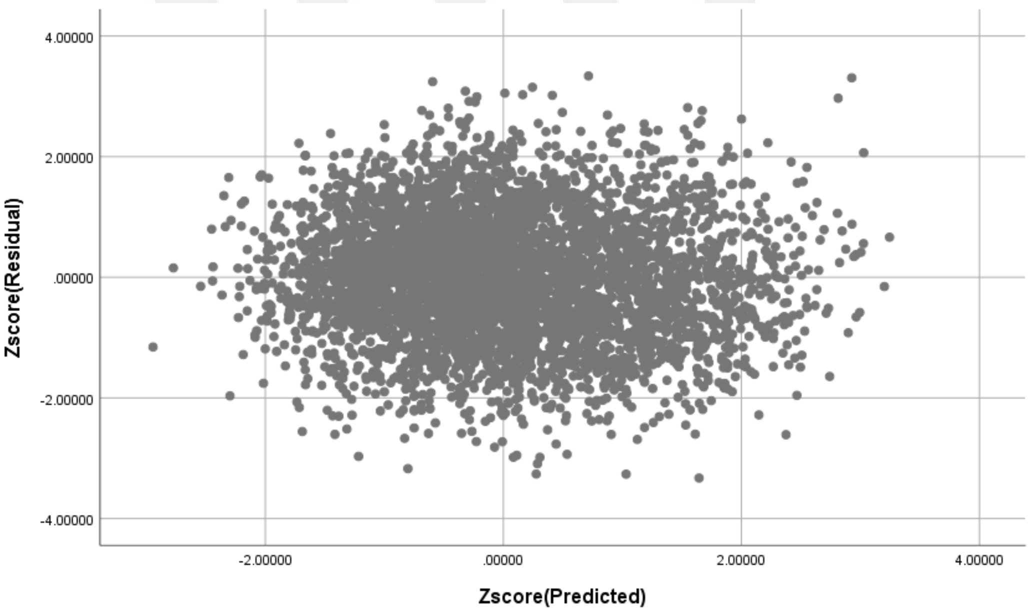

Figure 4.3. ZPRED and ZRESID histogram for Turkey.

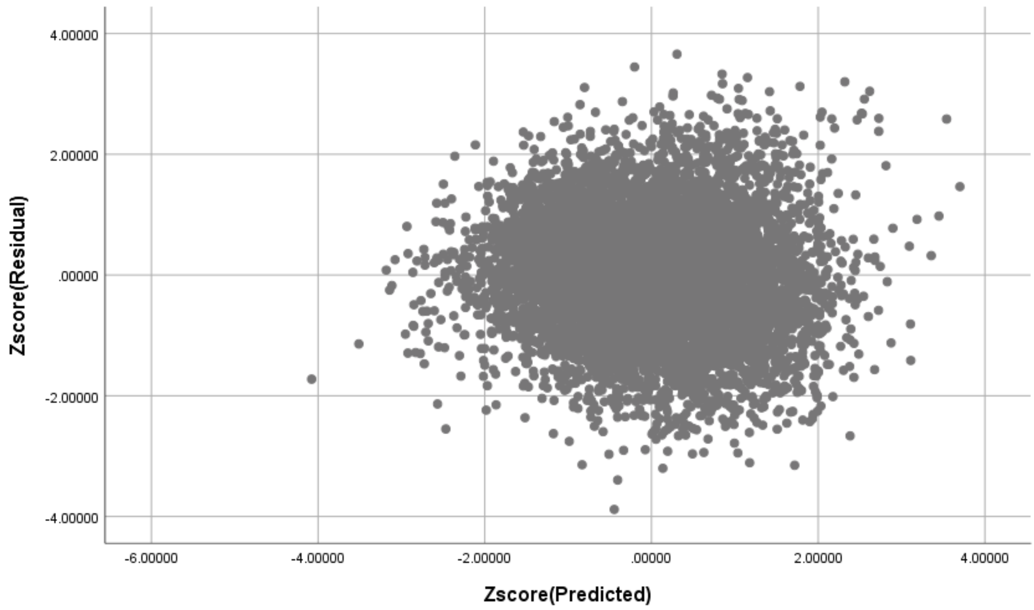

Figure 4.4. ZPRED and ZRESID histogram for Qatar.

4.2.3. Normality of Residuals

Normality curve of residuals for all variables were given below for each four countries separately. The assumption was not violated as the residuals were normally distributed.

Table 4.2. Skewness and kurtosis values.

	Ireland	**Peru**	**Turkey**	**Qatar**
Skewness	0.03	-0.039	0.038	0.03
Kurtosis	-0.059	0.014	-0.059	-0.059

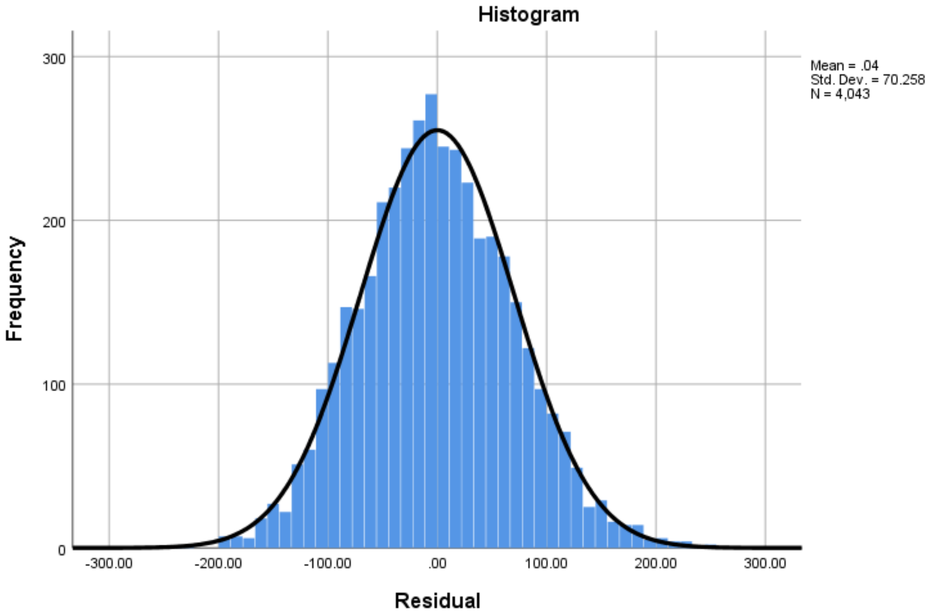

Figure 4.5. Normality curve for Ireland.

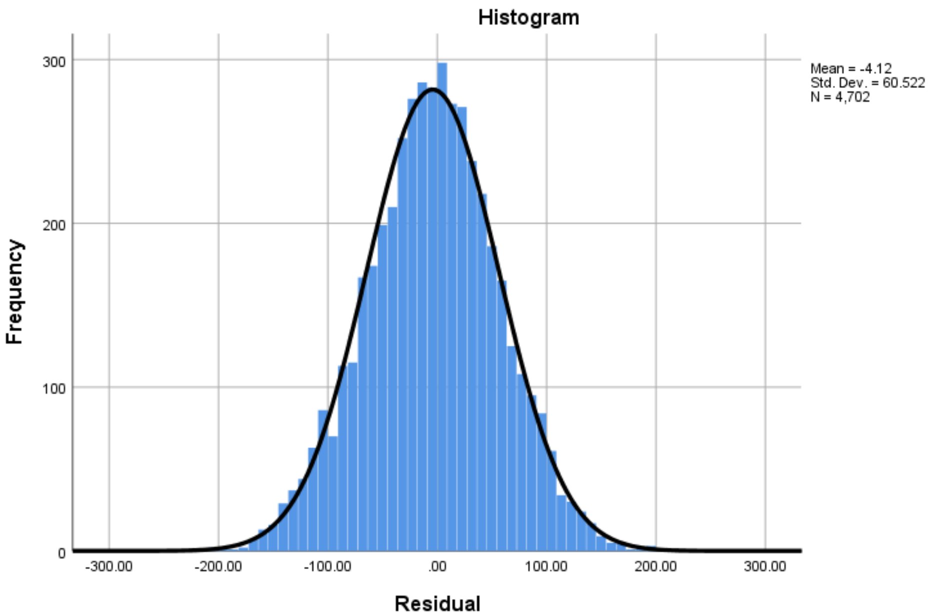

Figure 4.6. Normality curve for Peru.

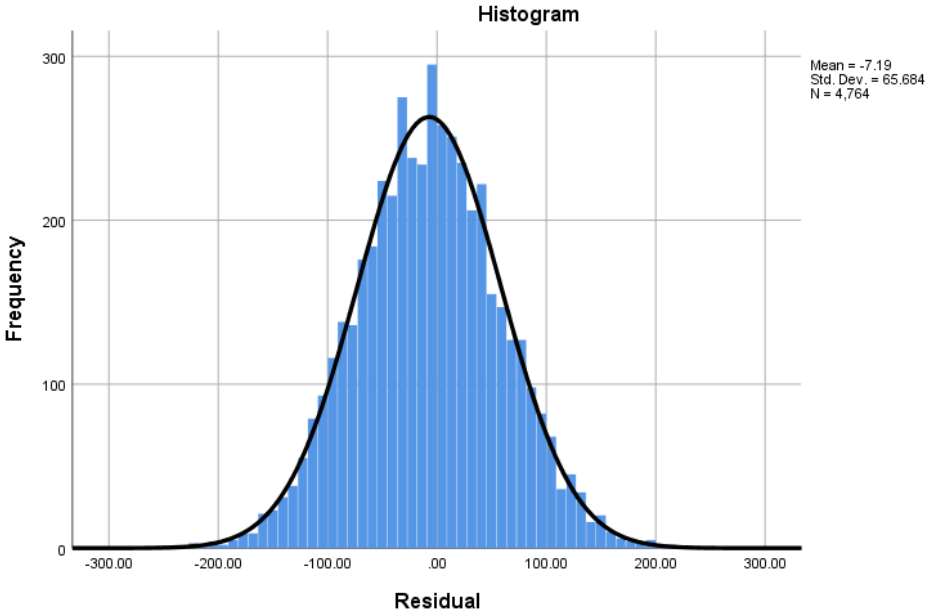

Figure 4.7. Normality curve for Turkey.

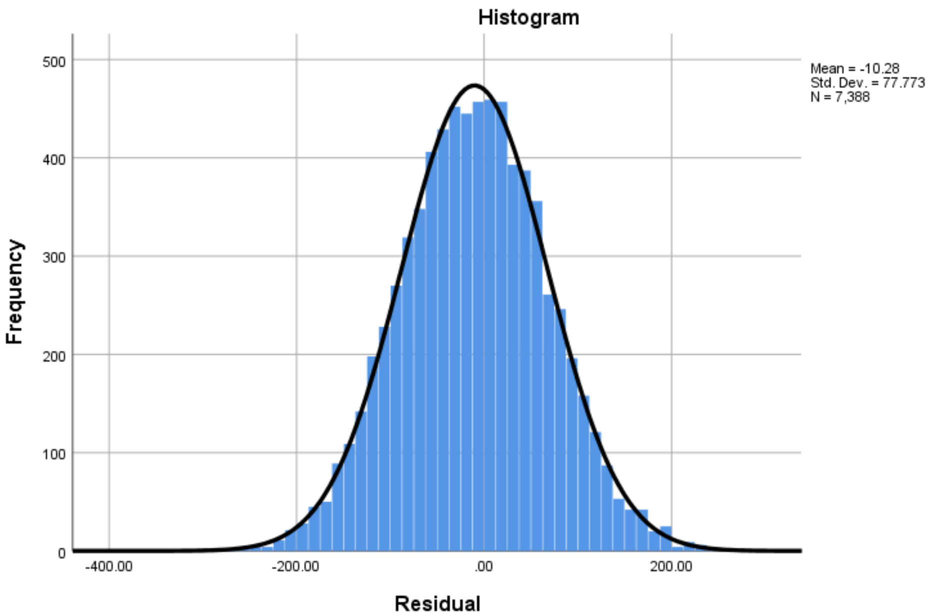

Figure 4.8. Normality curve for Qatar.

4.2.4. Multicollinearity

Correlation coefficients on Mplus were used to check the multicollinearity as Mplus takes into account the sample weights. Mplus calculated correlations among variables for each level separately, therefore two correlation matrix for each country were reported. The assumption of multicollinearity was no violated because there was not any high correlation among variables. The student- and school-level correlations are reported in Appendix C.

4.3. Two-level Regression Results

As stated in the methodology part, the two-level regression analysis was conducted in three parts. The results of the three models are given in this section.

4.3.1. Importance of the School Variability

In this section, the partitioning variances in science performance are discussed. The variances were analyzed in terms of student and school resources for each of the four countries (see Table 4.3.). For Turkey, approximately half of the variance in science performance was due to student characteristics (55%), and the other half to school characteristics (45%). For Qatar, student characteristics accounted for 73% of the total variance in science performance, and school characteristics explained 27%. For Peru, students' characteristics were responsible for 84% of the total variance in science performance, schools were responsible for approximately 16%. For Ireland, approximately 92% of the total variance in science performance was explained by students' characteristics, and 8% of the total variance in science performance was explained by schools and. As there were differences between schools, taking into account the school-level variables and conducting two-level regression was required.

Table 4.3. Intraclass correlation (ICC) values.

	Ireland	**Peru**	**Turkey**	**Qatar**
Science performance				
Between students	0.92	0.83	0.57	0.73
Between schools	0.08	0.16	0.45	0.27

4.3.2. Student-Level Model

As seen in Table 4.3.2, at the student-level, student perceptions about inquiry-based science instruction, and test anxiety were a statistically significant predictors of science performance for Qatar, Peru, Turkey, and Ireland ($p < .001$). There was a negative relationship between students' perceptions about inquiry-based science instruction, and test anxiety and science performance. This means that students who got high test anxiety got low science score and students who got low test anxiety had high science score. Enjoyment of science, science self-efficacy, epistemological beliefs were statistically significant positive predictor variables for the science performance of students for all four countries ($p < .001$). This means that students who had high enjoyment, self-efficacy, and epistemological beliefs for science lessons had high science performance score. While the index of science activities was also a statistically significant negative predictor for Qatar, Peru, and Turkey, it was a positive predictor for Ireland ($p < .001$). Additionally, disciplinary climate in science classes, achievement motivation and the highest parental education in years were positively and statistically significant predictors on students' science performance in Ireland, Peru, and Qatar ($p < .001$).

Estimated variance within school for student level model was the highest for Ireland with 30% and the lowest for Turkey with 9%. This means that student-level variables of the study could explain thirty percent of total difference between students in Ireland.

Table 4.4. Standardized regression coefficients for one level model (student- level).

	IRELAND	**PERU**	**TURKEY**	**QATAR**
Level- 1				
Disciplinary climate in science class	0.04**	0.04**	0.01	0.07***
Inquiry-based science instruction	-0.15***	-0.16***	-0.13***	-0.18***
Teacher directed science instruction	0.05**	0.05**	0.04*	0.07***
Enjoyment of science	0.19***	0.09***	0.11***	0.16***
Instrumental motivation	-0.02	-0.04*	0.02	0.09***
Science self-efficacy	0.14***	0.08***	0.07***	0.11***
Epistemological beliefs	0.18***	0.17***	0.12***	0.14***

Table 4.4. Standardized regression coefficients for one level model (student- level) (Cont.).

	IRELAND	PERU	TURKEY	QATAR
Index science activities	0.07***	0-.17***	-0.09***	-0.11***
Sense of belonging to school	-0.09***	0.09***	-0.02	0.01
Test-Anxiety	-0.17***	-0.14***	-0.11***	-0.11***
Achievement motivation	0.08***	0.14***	0.03	0.07***
Parents' emotional support	-0.02	-0.02	0.01	0.03**
Highest parental education	0.09***	0.11***	-0.01	0.06***
Cultural possession at home	0.08***	0.02	0.05*	-0.06***
Estimated variance within schools	0.3	0.2	0.09	0.22
*p < .05. **p<.01. ***p<0.001				

4.3.3. Student- and School- Level Model without ICT Resources

As seen in Table 4.3.3, the variables related to students' characteristics also were statistically significant for Turkey, Qatar, Peru, and Ireland after adding school-level variables. A statistically significant and positive relationship existed between students' enjoyment of science classes, science self-efficacy, and epistemological beliefs and their science performance. For Qatar, Peru, and Ireland, achievement motivation and highest parental education were statistically significant predictors of students' science performance. For Turkey, Qatar, and Ireland, cultural possession at home was statistically significant. On the other hand, students' considerations about the disciplinary climate in their science classes and instrumental motivation were statistically significant predictors for Qatar and Peru, but not for Turkey, and Ireland. A sense of belonging in school was a statistically significant predictor for Peru and Ireland. This means that students who had sense of belonging in their schools got higher science scores than others in Ireland and Peru. Finally, parents' emotional support was associated with science performance in Qatar only.

At level 2, there was no statistically significant variable for all four countries at the same time. For three countries- Turkey, Peru, and Ireland-, the index of science-specific performance was a statistically significant and positive predictor. This means that students who went to schools in which had more science specific resources showed higher science performance than others. For Qatar and Ireland, the number of available computers per student was a statistically significant predictor. On the other hand, for Turkey and Peru, the index proportion of science teachers to all teachers was a statistically significant variable but negatively for Peru, positively for Turkey. The index of the proportion of fully certificated science teachers, the index of the proportion of science teachers with an ISCED level5A and a major in science were a statistically significant predictor just for Qatar. Interestingly, classroom size, shortage of educational materials, and shortage of educational staff were statistically significant variables for Peru only.

Estimated variance between schools in the model were almost the same four countries as nearly 30% and the highest for Qatar with 32%.

Table 4.5. Standardized regression coefficients for two-level model (student- and school- levels) without the variable for ICT resources.

	IRELAND	**PERU**	**TURKEY**	**QATAR**
Level-1				
Disciplinary climate in science class	0.04	0.05**	0.02	0.06***
Inquiry based science instruction	-0.15***	-0.16***	-0.13***	-0.18***
Teacher directed science instruction	0.05**	0.05**	0.04*	0.07***
Enjoyment of science	0.20***	0.09***	0.11***	0.16***
Instrumental motivation	-0.02	-0.04*	0.02	0.09***
Science self-efficacy	0.13***	0.09***	0.07***	0.11***
Epistemological beliefs	0.17***	0.17***	0.13***	0.14***
Achievement motivation	0.08***	0.14***	0.03	0.07***
Parents' emotional support	-0.02	-0.02	0.01	0.04**
Highest parental education	0.10***	0.10***	-0.01	0.06***
Cultural possession at home	0.08***	0.02	0.05*	-0.06***
Level-2				
Classroom size	0.11	0.27**	0.09	-0.04
Numbers of available computers per student	-0.27**	0.1	-0.12	0.16*

Table 4.5. Standardized regression coefficients for two-level model (student- and school- levels) without the variable for ICT resources (cont.).

	IRELAND	PERU	TURKEY	QATAR
Index science activities	0.07**	-0.17***	-0.09***	-0.11***
Sense of belonging to school	-0.09***	0.08***	-0.02	0.01
Test-Anxiety	-0.18***	-0.15***	-0.11***	-0.11***
Shortage of educational materials	-0.11	-0.19*	-0.13	-0.02
Shortage of educational staff	-0.16	-0.19*	-0.12	-0.02
Index science teachers	0.13	-0.12*	0.28**	-0.02
Index science teachers fully certified	0.07	-0.01	0.03	-0.20*
Index science teachers with ISCED level 5A and a major in science	-0.03	-0.08	-0.01	0.39***
Index science specific resources	0.24*	0.14*	0.31***	-0.09
Estimated variance within schools	0.3	0.2	0.09	0.22
Estimated variance between schools	0.27	0.28	0.30	0.32
*p < .05. **p<.01. ***p<0.001.				

4.3.4. ICT Resources as a Predictor of Science Performance

Two-level regression analysis by adding ICT resources variable was re-conducted in order to analyze the effect of the variable on the science performance of the students (see Table 4.6). While for Turkey, and Peru, ICT resources was a positively and statistically significant variable associated with the science performance of students, for Qatar, and Ireland, it was not statistically significant while controlling student- and school-level variables. This means that students who had more ICT resources at their homes got higher science performance in Turkey and Peru. This relationship could not be found for Qatar and Ireland. On the other hand, ICT resources created a nearly 1% (0.08%) additional difference for science performance for Turkey and a nearly 4% (3.9) difference for Peru when controlling student- and school- levels variables. Based on the Figure 2.1, both Peru and Turkey had negative ICT resources averages, however, Peru had the most increase in students' science performance average and Turkey had the most decrease in students' science performance average in PISA 2015.

Table 4.6. Standardized regression coefficients for two-level model (student- and school- levels) including the variable for ICT resources.

	IRELAND	**PERU**	**TURKEY**	**QATAR**
Level-1				
Disciplinary climate in science class	0.04	0.05**	0.02	0.06***
Inquiry-based science instruction	-0.15***	-0.15***	-0.13***	-0.18***
Teacher directed science instruction	0.05**	0.05*	0.04*	0.07***
Enjoyment of science	0.20***	0.10***	0.11***	0.16***
Instrumental motivation	-0.02	-0.04*	0.02	0.09***
Science self-efficacy	0.14***	0.09***	0.07***	0.11***
Epistemological beliefs	0.17***	0.16***	0.13***	0.14***
Index science activities	0.07**	-0.16***	-0.09***	-0.11***
Sense of belonging to school	-0.09***	0.08***	-0.02	0.01
Test-Anxiety	-0.18***	-0.14***	-0.11***	-0.11***
Achievement motivation	0.08***	0.14***	0.04*	0.07***
Parents' emotional support	-0.02	-0.03	-0 .00	0.04**
Highest parental education	0.10***	0.07***	-0.02	0.06***
Cultural possession at home	0.08***	0.00	0.03	-0.05**
ICT resources	0.01	0.17***	0.08***	-0.03
Level-2				
Classroom size	0.11	0.23**	0.09	-0.04
Numbers of available computers per student	-0.27**	0.11	-0.12	0.16**
Shortage of educational materials	-0.11	-0.15	-0.13	-0.02
Shortage of educational staff	-0.16	-0.17	-0.12	-0.02
Index science teachers	0.13	-0.15**	0.28**	-0.02
Index science teachers fully certified	0.07	0.00	0.03	-0.20**
Index science teachers with ISCED level 5A and a major in science	-0.04	-0.08	0.00	0.39***
Index science specific resources	0.24*	0.12	0.32***	-0.08
Estimated variance within schools	0.30	0.24	0.09	0.22
Estimated variance between schools	0.27	0.25	0.31	0.32
*p < .005. **p<.01. ***p<0.001.				

5. DISCUSSION

This study aimed to explain the relationship between access to ICT resources at homes and other correlates and science performance average in PISA 2015 science performance based on data from four countries named Peru, Ireland, Turkey, and Qatar. Until 2012, there had been no major decrease in the science performance of students; however, in the PISA 2015, average science performance of the OECD countries fell to a minimum. That year, the PISA test was computer-based for the first time in almost all of the participating countries. A plausible reason for the low scores in the PISA 2015 could be students' lack of familiarity with ICT resources. Therefore, this study applied three models to investigate the effect of ICT resources on the PISA 2015 while controlling other possible factors. At the same time, many student and school-related variables based on the theoretical framework were investigated.

5.1. Two-Level Regression Models

The interpretations of the results of the two-level linear models are given in this section based on the three nested models.

5.1.1. Student-Level Model

For model I, the relationship between student-level variables and science performance of students were investigated and almost all of them were significant in explaining the science performance of students at least for one of the four countries. The situation supports the Equality of Educational Opportunity theory (Coleman *et al.*, 1966) because this theory emphasized the importance of student- level variables on academic achievement of students, and the student- level variables in this study were statistically significant for explaining science performance of students.

Enjoyment of science, science self-efficacy, and epistemological beliefs are statistically significant in predicting science performance of students for all four countries as in line with the studies of Bandura, (1994), Hampden-Thompson and Bennett (2011), Grabau and Ma, (2017), Fonseca *et al.* (2011), and Shumow *et al.* (2013). Students' consideration about disciplinary climate in their science classes, achievement motivation, and highest parental education in years are also positively and statistically significant for the three countries except for Turkey. This result supports previous findings for Qatar, Peru, and Ireland; however, it contradicts the previous results for Turkey because, Fuchs and Wöbmann, (2004), Güzeller and Şeker, (2016), and Tomul and Çelik's (2009) studies show us the importance of parental education; Shen Jen and Seng Yong (2013), Steinmayr *et al.* (2019) studies show us the importance of motivation to achievement on academic performance of 15-year-old students including Turkey. On the other hand, low parental education average around Turkey could be the reason for the situation for Turkey.

The relationship between inquiry-based science instruction and science performance of students is negatively and statistically significant for all four countries in this study. One of the reasons for this negative relationship among them could be questions in the test. Oliver, McConney, and Woods-McConney (2019) also conducted a research about the relationship between inquiry-based science instruction and science performance of students in PISA 2015 based on six countries including Canada, Australia, Ireland, New Zealand, UK, and USA and stated the need of framing the questions as "how often a teacher might use inquiry-based instruction and, for what purposes" instead of directly understanding there is inquiry based science instruction or not (p. 20) On the other hand, while this situation supports some findings in the literature, this result contradicts with some other research because the impact of inquiry-based science instruction on science performance of students is a controversial issue in literature. For example, according to the Anderson *et al.*, (2007), Costa and Araújo, (2018), and Bybee *et al.*'s (2006) studies, inquiry-based learning environment in science classes support science performance of students, however, Cairns and Areepattamannil (2019) and OECD (2016b) found statistically significant and negative relationship among them. In this study, while students' consideration of inquiry-based science instruction was negatively and statistically significant, teacher-directed science instruction is positively and statistically significant for all these four countries, although this situation promotes the literature.

On the other hand, the impact of instrumental motivation was changed among the four countries. The variable was statistically and negatively significant for Peru, and directly for Qatar. This result was consistent with the literature, since the relation between instrumental motivation and academic performance of students is a controversial issue also in the literature (Fonseca *et al.*, 2011; Grabau & Ma, 2017; Kula-Kartal & Kutlu, 2017).

Finally, test anxiety was negatively and statistically for all countries in the research and the result is consistent with OECD's (2016b) result.

5.1.2. Student- and School- Level Model without ICT Resources Variable

In the Model II, a two-level regression model was conducted based on student- and school-level variables. After adding the school-level variables, the impact of student-level variables was almost identical with the Model I result. The notable change was observed for the disciplinary climate in science classes for Ireland. In the first model, the variable was statistically significant for Ireland, but in the Model II result, the variable was not statistically significant.

The importance of school-level variables varied among the four countries. There was any common variable that was statistically significant for all the countries in the research at the same time. Only the variable of index science-specific resources was statistically significant with the science performance of students for Peru, Ireland, and Turkey. On the other hand, shortage of educational materials and staff were negatively and statistically significant only for Peru. However, this result is in contradiction with Areepattamannil (2014), Grabau (2016), and Sousa *et al.* (2012) studies. Because they claimed that physical factors including the shortage of educational materials and staff are relating to the science performance of students based on PISA 2006 and PISA 2009.

Finally, the relation between students' academic performance and teacher certification level changed from country to country in the literature (Fuchs & Wößmann, 2007; Grabau, 2016; Sharkey & Goldhaber, 2008), and the result of the Model II analysis was consistent with this finding. Because while the index proportion of science teachers with ISCED level 5A and a major in science were statistically and positively significant with the science performance of students in Qatar, but not in Ireland, Peru, and Turkey.

5.1.3. ICT Resources as a Predictor of Science Performance

In this study, Model III was created for understanding the importance of the ICT resources variable on students' science performance based on PISA 2015. The result of this analysis showed that if student- and school-levels variables would be equal, access to ICT resources at homes is still significant factor to predict science performance of students, especially in Turkey and Peru. Based on the Figure 2.1, Peru represents lower ICT resources on average and the highest increase in science performance difference country and Turkey represents lower ICT resources on average and the highest decrease in science performance country. Therefore, the result of this study implies that access to ICT resources is an important predictor for students from the countries which have lower ICT resources. This finding can be related to countries which have higher ICT resources in which students have more ICT resources at their homes. Because they have the resources, this variable may not be a statistically significant predictor of their academic performance. However, students from countries which have lower ICT resources like Turkey and Peru do not have equal access opportunities to ICT resources at their homes. Therefore, students' abilities to use ICT resources can differ during the test in the countries. The inequality might create science performance differences among students. Overall, it could be concluded that computer based version of PISA could be attributed to decrease in mean PISA science scores as ICT resources were significant predictor for countries with low ICT resources when controlling major student and school level variables.

5.2. The Importance of School Variability

For Turkey, 45 percent of the student score differences were due to differences among schools and this this difference between schools was the greatest compared to the other three countries. The reason for the situation could be school types in Turkey. 15 year olds are usually at high school level in Turkey. There are many types of high schools such as Science high schools, Anatolian high schools, Technical high schools, and Imam Hatip high schools. These schools accept students based on their high school entrance exam scores. The name of the exam is High School Entrance Exam (LGS) since 2018. Students who get higher scores go to the science high schools, and students who get lower scores go to the Imam hatip or Vocational high schools at the exam. Thus, students cluster based on their exam scores. This is a structural educational problem for Turkey. This situation indicates that Turkey needs to improve the equality in terms of science outcomes in its schools to create equal opportunities for 15-year-old students. One way to solve this problem could be to remove the exam and school types and students go to the high schools in their neighborhoods. Another way could be that to remove the exam and students go to these different types of high schools according to what they want to be and which profession they want to choose in the future. However, in this option, the quality of all high schools should be the same at high end and students should select these schools just according to the jobs they want to be in the future. On the other hand, according to the article by Topçu *et al.*(2015), between schools variance 55% in PISA 2006, and 52% in PISA 2009 in Turkey. Although there is a considerable decrease according to the year of 2006 (10%), 45 percentage of variance is still a lot.

Qatar was the second country with a 27% variance and Peru was third, with a 16.5% difference among schools. Ireland had the lowest percentage difference among its schools, at 8%. In conclusion, the overall results of this study support the Equality of Educational Opportunity Theory of Coleman *et al.* (1966) rather than the Heyneman-Loxley effect (1983).

5.3. Implications of This Study

In terms of policy implications, the results of this study showed that ICT resources are statistically significant predictors depending on the income level of countries and students' access to ICT resources at their homes. Policymakers in the upper-middle-income countries, which are Peru and Turkey in this study should give importance to accessibility to technology. They should promote and improve students' accessibility to technology at their homes. States should create equal opportunities for their citizens and students. If the situation could not be possible in a short time, there should be average that does not cause a difference among students in terms of access to ICT resources.

At the school level, schools, and families collaborate for decreasing test-anxiety of students because test-anxiety is statistically significant and inversely related to science performance for Ireland, Peru, Turkey, and Qatar.

Schools can organize conferences or event for their students' parents and teachers in order to teach them to promote and motivate their own children without pressure because OECD (2019c) stated that one of the possible reasons for test anxiety is high motivation created by parents and teachers. Additionally, teachers should consider how much science classes are enjoyable for students because the enjoyment of science topics in the four countries are statistically significant.

In terms of theoretical implications, there is a need for more research about the relationship between inquiry-based science instruction and science performance of students because this issue is controversial.

On the other hand, Peru and Turkey were upper middle-income countries and Ireland and Qatar were higher income countries in this study. In the result of the study, access to ICT resources was a significant predictor for science performance of students in Peru and Turkey, not in Qatar and Ireland. Therefore, the analysis based on income levels of countries could be conducted for understanding whether there is relationship between income levels of countries and science performance of students or not.

Additionally, Peru has lower ICT resources on average in PISA 2015. Although there is positively and statistically significant relationship between access to ICT resources at homes and science performance of students in Peru, science performance average of Peru increased in PISA 2015. The reason for the situation could be investigated to understand which factors contributed to increase science performance of students in Peru.

Finally, science self-efficacy and epistemological beliefs of students should promote by connecting science topics and the real world and the encouragement of students because of importance of them based on the analysis result.

5.4. Limitations of This Study

There are 64 countries attempted both 2012 and 2015 PISA tests and having ICT resources scores in PISA2015. This study is limited to four countries among them.

Additionally, there is the ICT Familiarity Questionnaire in PISA 2015. The survey includes questions related to students' availability of ICT, general computer use, use of ICT out of school and at school, attitudes towards computer (OECD, 2016b). However, students from Turkey and Qatar did not answer those questions. Therefore, this study is only included ICT resources as an ICT independent variable.

Finally, missing values were deleted from this study and the situation could threat representativeness of the sampling.

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APPENDIX A: List of PVs Differences and ICT Resources Averages

Table A.1. List of PVs differences and ICT resources average of the participant countries.

COUNTRIES	**PVDIFF**	**ICTRES**
Australia	-11	0.578931
Austria	-11	0.86717
Belgium	-3	0.1928
Brazil	-4	-1. 08433
Bulgaria	0	-0.28663
Canada	3	0.353412
Chienese Taipai	9	- 0.27 019
Chile	2	-0.65772
Colombia	17	-1.33921
Costa Rica	-9	- 0.9 0847
Croatia	-16	- 0.42 055
Czech Republic	-15	-1. 08 036
Denmark	4	0.767484
Estonia	-7	- 0. 03158
Finland	-14	0.1 06543
France	-4	- 0. 0713
Germany	-15	0. 058812
Greece	-12	-0.38861
Hong Kong(china)	-32	- 0.235 07
Hungary	-17	-0.29172
Iceland	-5	0.385391
Indonesia	21	-2. 01365
Ireland	-19	0.17577
Israel	-3	0. 016567
Italy	-13	-0.21735

Table a.1. List of PVs Differences and ICT Resources Average of the Countries (cont.).

COUNTRIES	**PVDIFF**	**ICTRES**
Japan	-9	- 0.62 077
Jordan	0	-0.78844
Korea	-22	-0.46976
Latvia	-12	- 0.228 08
Lithuania	-21	- 0.315 01
Luxembourg	-8	0.17813
Macao(China)	8	-0.17394
Mexico	1	-1.39983
Montenegro	1	-0.5336
Netherlands	-13	0.53889
New Zealand	-3	0.279592
Norway	3	0.6 08367
Peru	24	-1.61864
Poland	-25	-0.27538
Portugal	12	-0.22467
Qatar	34	0.624 083
Romania	-4	-0.76623
Russia	1	-0.33192
Singapore	5	0.19 0891
Slovak Republic	-1 0	- 0.2 0983
Slovenia	-1	- 0. 041 05
Spain	-3	- 0. 05465
Sweden	8	0.488445
Switzerland	-9	0.178762
Thailand	-23	-1.13751
Tunisia	-12	-1.27218
Turkey	-38	-1.17883
United Arap Emirates	-11	0.468773
United Kingdom	-5	0.562862
United States	-1	0.163432
Uruguay	19	- 0.69 0 06
Viet Nam	-3	-1.81149

APPENDIX B: Indicators of Home Possessions and Background Indices

Table B.1. Indicators of household possessions and home background indices.

ITEM	DESCRIPTION			Item is used to measure index		
		HOMEPOS	WEALTH	CULTPOSS	HEDRES	ICTRES
ST 011Q 01TA	A desk to study at	X			X	
ST 011Q 02TA	A room of your own	X	X			
ST 011Q 03TA	A quit place to study	X			X	
ST 011Q 04TA	A computer you can use for school work	X			X	
ST 011Q 05TA	Educational Software	X			X	X
ST 011Q 06TA	A link to the Internet	X	X			X
ST 011Q 07TA	Classic literature (e.g.<Shakspeare>)	X		X		
ST 011Q 08TA	Books of poetry	X		X		
ST 011Q 09TA	Works of art (e.g. paintings)	X		X		
ST 011Q1 0TA	Books to help with your school work	X			X	
ST 011Q11TA	<Technical Reference Books>	X			X	
ST 011Q12TA	A dictionary	X			X	
ST 011Q16NA	Books on art, music, or design	X		X		
ST 011Q17TA	<Country -specific wealth item 1>	X	X			
ST 011Q87TA	<Country -specific wealth item 2>	X	X			
ST 011Q19TA	<Country -specific wealth item 3>	X	X			
ST 012Q 01TA	Televisions	X	X			
ST 012Q 02TA	Cars	X	X			
ST 012Q 03TA	Room with a bath or shower	X	X			
ST 012Q 05NA	<Cell phones> with Internet access (e.g. smartphones)	X	X			X
ST 012Q 06NA	Computers (desktop computer, portable laptop, or notebook)	X	X			X
ST 012Q 07NA	<Tablet computers> (e.g. <iPad®>, <BlackBerry® PlayBookTM>)	X	X			X

Table b.1. Indicators of household possessions and home background indices (cont.).

ITEM	DESCRIPTION			Item is used to measure index		
		HOMEPOS	WEALTH	CULTPOSS	HEDRES	ICTRES
ST 012Q 08NA	E -book readers(e.g .<kindleTM>, <Kobo>, <Booken>)	X	X			X
ST 012Q 09NA	Musical instruments (e.g. guitar, piano)	X				
ST 013Q 01TA	How many books are t here in your home?	X		X		

APPENDIX C: Correlation Values for Student- and School-Level Variables

The tables of correlation values for students- and school- level variables for each country in this study were created to test the assumption of multicollinearity. Based on the tables, it was observed that the assumption was met.

Table C.1. Correlation values for student-level variables (IRELAND).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	1.000															
2	0.074	1.000														
3	-0.027	0.218	1.000													
4	0.088	0.236	0.541	1.000												
5	0.377	0.184	0.236	0.261	1.000											
6	0.171	0.109	0.191	0.167	0.472	1.000										
7	0.351	0.078	0.175	0.163	0.464	0.297	1.000									
8	0.323	0.063	0.078	0.134	0.344	0.205	0.276	1.000								
9	0.313	0.042	0.189	0.162	0.544	0.317	0.462	0.244	1.000							
10	-0.016	0.112	0.114	0.105	0.075	0.076	0.085	0.076	-0.012	1.000						
11	-0.202	-0.078	-0.012	-0.025	-0.081	0.012	-0.115	-0.019	-0.039	-0.205	1.000					
12	0.198	-0.014	0.053	0.084	0.238	0.234	0.244	0.211	0.202	0.158	0.015	1.000				
13	0.046	0.085	0.129	0.141	0.121	0.139	0.088	0.107	0.066	0.219	-0.031	0.234	1.000			
14	0.19	-0.025	-0.004	0.009	0.074	0.058	0.138	0.095	0.117	0.219	-0.038	0.083	0.049	1.000		
15	0.222	0.025	0.07	0.073	0.163	0.094	0.258	0.147	0.278	-0.008	-0.022	0.094	0.137	0.263	1.000	
16	0.078	-0.006	0.028	0.011	0.047	0.038	0.102	0.044	0.084	0.076	-0.013	0.09	0.107	0.197	0.233	1.000

(1: PVSCIENCE, 2: DISCLISC, 3: IBTEACH, 4: TDTEACH, 5: JOYSCIE, 6: INSTSCIE, 7: SCIEEFF, 8: EPIST
9: SCIEACT, 10: BELONG, 11: ANXTEST, 12: MOTIVAT, 13: EMOSUPS, 14: PARED, 15: CULTPOSS, 16: ICTRES)

Table C.2. Correlation values for school-level variables (IRELAND).

	1	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1	1.000								
17	0.193	1.000							
18	-0.296	-0.277	1.000						
19	-0.280	0.005	-0.026	1.000					
20	-0.257	0.035	0.040	0.427	1.000				
21	0.069	-0.072	-0.015	0.120	0.160	1.000			
22	0.056	-0.012	-0.041	0.072	0.038	0.196	1.000		
23	-0.061	-0.201	0.090	0.031	-0.039	0.002	0.418	1.000	
24	0.307	0.060	0.070	-0.509	-0.256	-0.124	-0.069	-0.036	1.000
(1: PVSCIENCE, 17: CLSIZE, 18: RATCMP1, 19: EDUSHORT, 20: STAFFSHORT, 21: PROSTAT, 22: PROSTCE, 23: PROSTMAS, 24: SCIERES)									

Table C.3. Correlation values for student-level variables (PERU).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	1.000															
2	0.072	1.000														
3	-0.160	0.123	1.000													
4	0.030	0.181	0.44	1.000												
5	0.143	0.108	0.129	0.209	1.000											
6	-0.031	0.065	0.176	0.131	0.200	1.000										
7	0.085	0.028	0.194	0.135	0.203	0.212	1.000									
8	0.258	0.064	0.019	0.118	0.294	0.086	0.072	1.000								
9	-0.162	0.021	0.296	0.180	0.232	0.214	0.327	-0.009	1.000							
10	0.177	0.130	0.052	0.110	0.103	0.094	0.053	0.150	-0.038	1.000						
11	-0.140	-0.070	-0.029	-0.014	-0.043	0.017	-0.140	0.035	-0.049	-0.074	1.000					
12	0.186	0.004	0.015	0.103	0.181	0.144	0.132	0.192	0.077	0.167	0.137	1.000				
13	0.062	0.136	0.114	0.127	0.136	0.103	0.074	0.128	0.077	0.204	0.017	0.250	1.000			
14	0.192	-0.012	-0.053	0.002	0.015	-0.011	0.065	0.088	-0.030	0.064	-0.032	0.080	0.055	1.000		
15	0.062	0.024	0.091	0.074	0.086	0.044	0.154	0.071	0.214	0.057	-0.069	0.084	0.128	0.176	1.000	
16	0.263	-0.004	-0.099	0.020	-0.045	-0.065	0.035	0.131	-0.082	0.112	-0.015	0.067	0.119	0.425	0.246	1.000

(1: PVSCIENCE, 2: DISCLISC, 3: IBTEACH, 4: TDTEACH, 5: JOYSCIE, 6: INSTSCIE, 7: SCIEEFF, 8: EPIST
9: SCIEACT, 10: BELONG, 11: ANXTEST, 12: MOTIVAT, 13: EMOSUPS, 14: PARED, 15: CULTPOSS, 16: ICTRES)

Table C.4. Correlation values for school-level variables (PERU).

	1	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1	1.000								
17	0.289	1.000							
18	0.108	-0.175	1.000						
19	-0.287	-0.006	-0.1791	1.000					
20	-0.301	-0.075	-0.062	0.5241	1.000				
21	-0.207	-0.196	0.055	-0.006	0.0221	1.000			
22	0.049	0.093	0.003	0.056	0.013	-0.1681	1.000		
23	-0.090	-0.077	-0.001	-0.028	-0.045	0.017	0.030	1.000	
24	0.286	0.291	0.059	-0.242	-0.236	-0.142	0.158	-0.001	1.000
(1: PVSCIENCE, 17: CLSIZE, 18: RATCMP1, 19: EDUSHORT, 20: STAFFSHORT, 21: PROSTAT, 22: PROSTCE, 23: PROSTMAS, 24: SCIERES)									

Table C.5. Correlation values for student-level variables (TURKEY).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	1.000															
2	0.062	1.000														
3	-0.118	0.065	1.000													
4	0.069	0.172	0.126	1.000												
5	0.152	0.168	0.094	0.193	1.000											
6	0.044	0.053	0.115	0.052	0.145	1.000										
7	0.072	0.054	0.157	0.030	0.149	0.271	1.000									
8	0.187	0.077	-0.020	0.137	0.299	0.073	0.062	1.000								
9	-0.053	0.001	0.240	0.038	0.269	0.142	0.315	-0.026	1.000							
10	0.019	0.074	0.027	0.077	0.044	0.122	0.076	0.102	-0.031	1.000						
11	-0.090	-0.092	-0.073	0.006	-0.052	0.006	-0.053	0.034	-0.093	-0.036	1.000					
12	0.072	0.052	-0.005	0.100	0.174	0.099	0.091	0.195	0.002	0.064	0.235	1.000				
13	0.069	0.157	0.079	0.132	0.165	0.108	0.058	0.049	0.017	0.013	0.026	0.298	1.000			
14	0.022	-0.026	-0.025	-0.016	0.004	-0.024	0.142	0.096	0.112	0.069	-0.011	0.006	0.090	1.000		
15	0.077	0.030	0.045	0.060	0.088	0.034	0.063	0.101	0.029	0.075	-0.021	0.08	0.217	0.272	1.000	
16	0.114	0.000	-0.056	0.026	0.011	-0.001	0.035	0.131	-0.082	0.112	0.008	0.044	0.201	0.349	0.406	1.000

(1: PVSCIENCE, 2: DISCLISC, 3: IBTEACH, 4: TDTEACH, 5: JOYSCIE, 6: INSTSCIE, 7: SCIEEFF, 8: EPIST 9: SCIEACT, 10: BELONG, 11: ANXTEST, 12: MOTIVAT, 13: EMOSUPS, 14: PARED, 15: CULTPOSS, 16: ICTRES)

Table C.6. Correlation values for school-level variables (TURKEY).

	1	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1	1.000								
17	0.056	1.000							
18	0.042	-0.18	1.000						
19	-0.325	-0.023	-0.088	1.000					
20	-0.334	0.033	-0.131	0.51	1.000				
21	0.308	-0.214	0.331	-0.077	-0.207	1.000			
22	0.041	0.185	-0.106	-0.058	-0.015	-0.088	1.000		
23	0.049	0.066	0.043	-0.077	-0.132	-0.002	0.035	1.000	
24	0.431	-0.004	0.214	-0.388	-0.356	0.181	-0.013	0.077	1.000
(1: PVSCIENCE, 17: CLSIZE, 18: RATCMP1, 19: EDUSHORT, 20: STAFFSHORT, 21: PROSTAT, 22: PROSTCE, 23: PROSTMAS, 24: SCIERES)									

Table C.7. Correlation values for student-level variables (QATAR).

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
1	1.000															
2	0.175	1 .000														
3	-0.132	0.019	1.000													
4	0.161	0.242	0.209	1.000												
5	0.288	0.185	0.114	0.265	1.000											
6	0.194	0.103	0.140	0.112	0.286	1.000										
7	0.164	0.078	0.181	0.060	0.225	0.328	1.000									
8	0.294	0.169	-0.009	0.225	0.410	0.176	0.133	1.000								
9	-0.076	-0.040	0.220	0.018	0.187	0.195	0.300	-0.061	1.000							
10	0.118	0.172	0.125	0.159	0.173	0.154	0.124	0.140	0.000	1.000						
11	-0.120	-0.081	-0.025	-0.003	0.040	-0.039	-0.110	0.014	-0.050	-0.114	1.000					
12	0.160	0.070	0.045	0.155	0.215	0.145	0.129	0.170	0.016	0.187	0.133	1.000				
13	0.153	0.190	0.077	0.171	0.195	0.156	0.121	0.195	0.023	0.235	-0.026	0.296	1.000			
14	0.113	0.072	-0.072	0.040	0.057	0.049	0.076	0.088	0.017	0.012	-0.059	0.010	0.050	1.000		
15	-0.006	0.073	0.042	0.063	0.090	0.029	0.157	0.079	0.102	0.052	-0.034	0.032	0.119	0.174	1.000	
16	-0.019	0.027	0.051	0.068	0.000	-0.039	0.035	0.032	-0.031	0.084	0.021	0.133	0.146	0.119	0.325	1.000

(1: PVSCIENCE, 2: DISCLISC, 3: IBTEACH, 4: TDTEACH, 5: JOYSCIE, 6: INSTSCIE, 7: SCIEEFF, 8: EPIST 9: SCIEACT, 10: BELONG, 11: ANXTEST, 12: MOTIVAT, 13: EMOSUPS, 14: PARED, 15: CULTPOSS, 16: ICTRES)

Table C.8. Correlation values for school-level variables (QATAR).

	1	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1	1.000								
17	-0.156	1.000							
18	0.213	-0.321	1.000						
19	-0.029	-0.054	0.011	1.000					
20	-0.030	-0.077	0.013	0.396	1.000				
21	-0.159	0.071	-0.178	-0.031	0.018	1.000			
22	-0.358	0.077	-0.123	0.075	0.054	0.088	1.000		
23	0.482	-0.092	0.028	-0.049	-0.04	-0.215	-0.318	1.000	
24	-0.143	0.122	0.052	-0.359	-0.245	0.056	0.102	-0.136	1.000
(1: PVSCIENCE, 17: CLSIZE, 18: RATCMP1, 19: EDUSHORT, 20: STAFFSHORT, 21: PROSTAT, 22: PROSTCE, 23: PROSTMAS, 24: SCIERES)									