EXPLORING THE RELATIONSHIP BETWEEN STUDENTS' MATHEMATICS LITERACY AND THEIR ACCESS TO AND USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT): USING PISA 2012 DATA

by
Tebong Lawrence Tezoh
B.S., Mathematics Education, ENS Annex Bambili, University of Yaoundé 1, 2007

Submitted to the institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science

Graduate Program in Secondary School Science and Mathematics Education
Boğaziçi University
2015

ACKNOWLEDGEMENT

To begin with, I can never thank my thesis supervisor; Fatih Çağlayan Mercan enough for his relentless support and genuine words of encouragement to see that this academic exercise successful serve its goal. In short, he was always available for assistance and he did every possible best to motivate me and help me pick myself up, especially when he noticed signs of apathy in me. I was truly lucky to have work with such a passionate lecturer as my supervisor.

Of course, the precious time sacrificed to review and the critical comments made by the thesis defense committee members, Fatma Aslan Tutak and Serkan Özel can never go unnoticed. I am so thankful for their professionalism.

I also want to express my sincere gratitude to my dearest friend Tugay Durak, who assisted in the translation of the thesis abstract (Özet) form English to Turkish.

Lastly, I would like to express my profound love and appreciation to my beloved wife, Jacqueline Eyen and my children, Tezoh Tebong Junior and Tezoh Philijoy Ambock for their patience, understanding and support during this academic battle.

ABSTRACT

EXPLORING THE RELATIONSHIP BETWEEN STUDENTS' MATHEMATICS LITERACY AND THEIR ACCESS TO AND USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICT): USING PISA 2012 DATA

A significant amount of resources are being spent for Information and Communication Technology (ICT) accessibility at schools and at homes, with the hope of increasing student outcomes. However, the relationship between ICT availability and use and mathematics literacy is far from being settled. Existing studies provide conflicting results related to this relationship. The Program for International Students Assessment (PISA) has been conducted five times from 2000 to 2012, to measure 15-year-old students' literacies in Reading, Mathematics and Science. PISA 2012 data provides information from nationally representative samples, for at least for 37 countries, which allows for testing the degree to which ICT availability and use predicts mathematics literacy. The purpose of this study is to examine the relationship between ICT availability, ICT use, and students' economic, socioand cultural status (ESCS) as predictor variables and mathematics literacy as criterion variable using the dataset of the PISA 2012 for 37 selected countries and economies. Multiple Linear Regression analyses were conducted in order to determine the degree of association between the criterion variable and the predictor variables. In order to find patterns of similarities and differences among the 37 countries in terms of regression coefficients strength of the ICT availability and use variables, the results of the analyses was explored. The index of students' ESCS exerted the most significant influence on mathematics literacy in all 37 countries, followed by ICT use at home variable that had a considerable impact on students' mathematics literacy in more than 65% the 37 selected countries. The conclusion is that as a key factor for improvingmathematics literacy mean scores on PISA test at country level is to equitably distribute social capital on the schools, alternatively, less monies should be spent on school ICTs but on home ICTs through government subvention and subsidy programs.

ÖZET

ÖĞRENCİLERİN MATEMATİK OKURYAZARLIĞI İLE BİLGİ VE İLETİŞİM TEKNOLOJİLERİ (BİT) ERİŞİMİ VE KULLANIMI ARASINDAKİ İLİŞKİNİN PİSA 2012 VERİSİYLE İNCELENMESİ

Öğrenci başarısını artırmak ümidiyle Bilgi ve Komünikasyon Teknolojisi (BİT) erişilebilirliğine önemli miktarda kaynak ayrılmaktadır. Fakat ICT erişilebilirliği ve kullanımı ile matematik okur-yazarlığı arasındaki ilişkinin doğası kesin olarak bilinmemektedir. Yapılmış olan araştırmalar bu ilişkiyle ilgili çelişkili sonuçlara varmaktadır. Uluslararası Öğrenci Değerlendirme Programı (PISA), pek çok ülkedeki 15 yaşındaki öğrencilerin Okuma, Matematik ve Fen alanlarındaki okuryazarlığını ölçmek için 2000'den 2012'ye kadar 5 kez gerçekleştirilmiştir.Bu araştırmada 37 ülkeden toplanmış ulusal temsil niteliği olan PISA 2012 verileri kullanılarak BİT erişilebilirliğinin, BİT kullanımının ve öğrencilerin ekonomik, sosyo ve kültürel statülerinin (ESCS) Matematik okuryazarlığını hangi düzeyde öngörebildiği incelenmiştir.Kriter değişken ve tahmin değişkenleri arasındaki ilişkinin derecesini belirlemek için Çoklu Doğrusal Regresyon analizleri yapılmıştır. BİT erişilebilirliği ve kullanımı değişkenlerinin regresyon katsayıları büyüklükleri açısından 37 ülke arasındaki benzerlikleri ve farklılıkları bulmak için analizlerin sonuçları incelenmiştir. Sonuçlar ESCS'nin matematik okuryazarlığını en yüksek oranda öngören değişken olduğunu, evde BİT kullanımı değişkeninin de 37 ülkenin %65'inde ikinci önemli tahmin değişkeni olduğunu göstermiştir. Matematik okuryazarlığını geliştirmek için kilit unsur olan okullardaki sosyal sermayenin adaletli biçimde dağıtılması; devlet desteği ve yardımının okullardaki değil öğrencilerin evlerindeki BİT erişilebilirliğini ve kullanımını geliştirmek için yönlendirilmesi önerilmektedir.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/ABRREVIATIONS

ESCS	Economic, Social and Cultural Status
ICT	In formation and Communication Technology
ICTHOME	ICT availability at home
ICTSCH	ICT availability at school
MLR	Multiple Linear Regressions
OECD	Organization of Economic Cooperation and Development
PISA	Program for International Students Assessment
PV	Plausible Value
TIMSS	Trends in International Mathematics and Science Study
USEHOME	ICT use at home
USEMATH	ICT use for Mathematics lessons
USESCH	ICT use at school

1. INTRODUCTION

Information and Communication Technology (ICT) is ubiquitous throughout business sector and it has found its way into the educational sector as well. Nowadays, it is not surprising to find middle school students owning and using latest versions of assorted ICT gadgets both in and out of school. In this study, ICT encompasses hand held computing devices, home and school Internet, mobile and desktop computing and communicating devices that open a gateway to the digital information world through telecommunication. Among educational researchers and other stakeholders in education, this phenomenon of young students' possession and intense utilization of ICTs has raised the pertinent question of whether possession and usage of ICTs actually promote or hinder their mathematics literacy.

There are two opposing views on whether students should be provided with ICT-related facilities or not. Some people argue that modern ICTs for children contain many learning enhancement applications for almost every school subject and at different grade levels too, thus the provision of ICT opportunities to young students will not only help them in improving academic performance across all disciplines, but will also help them stay up-to-date in this fast technologically driven world (Notten & Kraaykamp, 2009). On the contrary, others argue that the exposure of young students to the world of ICT will make them more vulnerable to the world of learning distraction and immoralities, since they would likely spend most of their valuable studying time in playing computer games, social networking, and visiting inappropriate sites on the internet (Becker, 2000).

Although existing evidence emerging from research findings on the influence of ICT on students' learning are contradictory in nature, there is still a widely held belief that the possession and usage of ICTs are predetermining factors for students' success in school (Van Damme, 2003). This explains why many educational authorities do not only recommend or emphasize the use of ICTs for teaching in the classroom but they offer supportive measures for teachers' effective integration of ICT tools in school.Forexample, providing technical and pedagogical support, ensuring availability of ICT in varieties, providing guides on classroom management and teaching with diverse resources of ICTs (Condie & Munro, 2007). The enthusiasm of these policy-makers is driven by the belief that the usage of ICT by both students and teachers in teaching and learning would yield greater academic returns, in which the students stand to benefit most.

A recent survey shows that, in a typical secondary school among member countries of the Organization of Economic Corporation and Development (OECD), the average number of computers per student was estimated to have increased by twice within only three years (OECD, 2010). In 2000, the ratio was 1 computer to 10 students and in 2003 the ratio doubled to 1 to 5. The same observation was reported with secondary schools' Internet availability and accessibility; in 1995, while less than 25% of OECD secondary schools had access to Internet with broadband connectivity; the figures skyrocketed to more than 80% by the year 2001 (OECD, 2010).

Based on the belief that ICT accessibility and usage in school can boostmathematics literacy, most governments around the world continuously strive to provide ICT accessibility within their schools systems. However, some authorities do so, only with a lot of precaution measures. For example, Güven (2014) reported that Turkey has been following the surging trend of implementing public investment schemes on ICT infrastructure, while at the same time, in the name of protecting minors, screening and banning access to certain websites that are deemed to be indecent and harmful to young students. The conflicting decisions made in Turkey nicely illustrate the controversy that surrounds the provision of ICTs to young students.

The rest of this paper is assembled in the following organizational structure; section two views the literature, section three significant of the study, section four statement of the problem, section fivedescribes the methodology employed, section six presents the results and section seven discuss and conclude.

2. LITERATURE REVIEW

2.1. Introduction

With the proliferation and diffusion of ICT into schools and homes, a growing number of school children are possessing and using ICT in almost every aspect in their daily lives. A phenomenon has attracted the attention of many educational researchers, as well as educational policy-makers to ponder on whether the wide use of these technological devices actually have any relationship with students' mathematics literacy, and if so, what kind of relationship?

Beside anoverview of OCED's PISA project, the following section is aimed at presenting what theories and research have documented on the use of ICT andmathematics literacy. From these perspectives, can a clear relationship be found between availability and use of ICT and students' mathematics literacy?

2.2. An Overview of the Organization for Economic Co-operation and Development (OECD)

OECD is an organization that is typically concerned with the promotion of policies that can positively impact the economic and social well being of people around the world. It is made up of 34 countries; Australia, Austria, Belgium, Canada, Chile, Czech Republic, Demark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States (OECD, 2014). OECD achieve its goals by creating a forum in which member governments work together by sharing ideas and experiences in seeking solution to a common problem. The OECD works in collaboration with governments to look into issues that directly affects individuals' daily life; such as understanding change patterns in economies, societies, and environment. Based on facts and real-life experiences, OECD suggests polices and practices designed to promote quality standards for all citizens.

The organization strives to set international standards on a wide range of issues not limited to education and it does so by analyzing and comparing high quality survey data to predict future trends. Among OCED'ssponsored projectis the Program for International Students Assessment (PISA) survey, which evaluates and compares the education systems among its 65 member countries and economies. PISA assesses the knowledge and skills of 15-years-old students in specific subject areas, to determine their readiness level to face real-life challenges using the knowledge and skills acquired from formal schooling (OCED, 2013).

2.3. The Program for International Students Assessment (PISA)

In nearly all countries around the world, monitoring and evaluation systems are instituted in schools to assess the effectiveness of educational programs. The systems measure students' learning and estimate how well they are prepared for real future life challenges. It is because many people believe that becoming a successful citizen; certain basic knowledge and skills are necessary for meaningful integration and participation in the society. It is therefore important to understand the extent to which young students graduating from mandatory schooling are adequately prepared to apply the knowledge and skill learned in the classroom to a multitude of situations pending in their future lives.

In response to this need, OECD launched PISA in 2000; to assess the extent to which 15-year-old students in all 34 OECD member countries and 31 partner countries and economies have achieved key classroom knowledge and skills essential for full participation in society (OCED, 2013). Since PISA is interested in 15-year-olds' knowledge and skills for life application in a multitude of contexts, rather than knowledge and skills acquisition as defined in national curricula, it is an age-based assessment and not a grade-basedtest. This international standardized assessment project targets only students between the ages of 15 years 3 months and 16 years 2 months at the time of the assessment. In most countries, 15-year-old students are considered to be near the end of their compulsory secondary education and must have acquired the basic array of knowledge and skills necessary for a meaningful integration in to the society. It therefore represents an ideal reference point to determine the outputs of an education system and evaluate its effectiveness (OCED, 2013).

PISA uses high quality test items and questionnaires to collect reliable and valid data form each participating countries. Within countries, between 4,500 and 10,000 students are selected from at least 150 public or private schools, using a statistical framework that ensures representative sampling of all 15-years old students in the country. From the selected students, who are either enrolled in an academic or a vocational program, the results are weighted and analyzed to infer the characteristic of the entire student population (OCED, 2013).

As an on-going assessment project conducted every three years, PISA is able to keep track of the educational progress of each participating country and economy. PISA can therefore rank education systems based on their performance level and provide insightful information on factors influencing educational outcomes. Principally, PISA evaluates 15-year-old students in the domain of reading, mathematics and science literacy, not in terms of curriculum content mastery but in terms of knowledge and skills applicability (OCED, 2013). Therefore, literacy level in PISA results predicts how well the students are able to apply their school knowledge to real-life situations and equipped to face the challenges of future life (OCED, 2013).

Besides the assessment of these three specific areas, the PISA survey also gathers background information from school authorities (e.g. principals), students and parents on various economic, social, and cultural factors affecting the teaching and learning process. This information is expected to inform policy-makers and educators on sensitive issues related to students' mathematics literacy and the overall growth of the education system. Each cycle of PISA usually focuses on one of the three assessment domains. For PISA 2012, the focal domain was mathematics, which featured problem-solving items to measure various components of mathematics literacy (OCED, 2013).

PISA's success is increasingly reflected in the changing trend in school curricula across many nations that are focusing on what students can do with the knowledge and skills learned in the classroom rather than mastering specific curricular content (OCED, 2013). This changing trend in the curriculum is also fuelled by the way individuals seem to be rewarded in today's economy based on what they can do with what they know, rather than what they know only (Kubiatko & Vlckova, 2010).

The prevalence of knowledge and skills measured by PISA is supported by recent studies that aim at tracking students who took the PISA testfew years after. Some evidence argued that students' performance in future life can be predicted by students' specific literacy on the PISA test. For example, Canadian students who had attained reading proficiency level 5 on the PISA test at age15, were 16times more likely to be enrolled and success in a post secondary studies at their 19s, than their counterparts who had not attained the reading proficiency level 1 (OECD, 2013).

2.4. How PISA Reports Students' Literacy Level

In an educational assessment, the difference between the reported test score and the actual score constitute what is known as measurement error. Measurement error is not always independent of the proficiency level of the students. However, it may be smaller for average students, larger for low achievers and high achievers, depending on the difficulty of the test items. In order to infer students' test scores to a larger population, it is important to minimize the measurement error associated with individual's estimates (Brookhart, Susan & Nitko, 2012).

PISA reports students' literacy level using five plausible values on a continuous scale, with each plausible value being a random score from the set of scores that can possibly be attributed to each student. The internal reliability estimate of the plausible values was .99 (OECD, 2013).

2.5. Generalizability of PISA Results to 15-year-olds

Specifically, PISA 2012 employs a two-stage stratification sampling technique for selecting participants within the qualified schools in each country. A systematic sampling of schools is conducted based on geographical locations and criteria of students, followed by a random selection of thirty-five 15-year-old students within each participating school (OCED, 2013).In the PISA 2012, after thoroughly scrutinizing the developed test items for specific domains, test booklets were formed from a number of units developed at different test development centers. These booklets were pilot tested with several classes of 15-year-old students in several different schools in some of the participating countries and economies. Data collected from the pilot and field-testing were analyzed using standard item response theory techniques. An important outcome of these pilot studies was the generation of many student responses to each constructed-response item (OCED, 2013).

For a set of data collected from a sample to be generalizable to a population, the sample must be true representative of the target population (Creswell, 2012). PISA data are collected from specific group students, in a specific setting and at a specific point in time. The students, test materials, tasks, and so on, are selected in a manner that guarantee the conclusion researched, from analyzing data of a specific group of students holds true for a variety of settings and thus valid to a greater degree to the target population of 15-year-old students. In addition to the large representative samples, the detailed analyses techniquesemployed by PISA, allow for results to be generalizable within and across countries (OCED, 2014). Usually, the generalization of PISA results to 15-year-old students across countries and economies, often trigger the curiosity of researchers and theorists to find factors that are explainable for effective learning of school subject such as mathematics. One of such explanatory factor is ICT use in education; of which good amount literatures have been documented to show the influence of ICT use on mathematics learning, as we see in the next section.

2.6. Influence of ICTs on Mathematics Learning

Most ICT tools have the potential of offering students with numerous learning opportunities, not limited to searching relevant information on the computer and Internet (Dumais, 2009). In addition, some ICTs enable the receiving and submitting online homework, broadening and deepening of knowledge, testing and evaluating understanding through an interactive online and offline learning programs (Yusuf & Afolabi, 2010).

The National Council of Mathematics Teachers (NCTM) has repeatedly advocated for the incorporation of ICT into the teaching and learning of Mathematics as the main means of improving mathematics literacy. It is adopted as one of the six principles for mathematics education and stated as, "technology is essential in teaching and learning mathematics; it influence the mathematics that is taught and enhance students' understanding and learning" (NCTM, 2000, p. 24).

In formulating the *cognitive theory of multimedia learning*, Mayer (2001) emphasized the advantage of using multimedia tools such as the computer and Internet in teaching children. According to Mayer, if multimedia (ICT) is appropriately used in the classroom, they can activate multiple senses (i.e. the visual, the auditory and the text-based communication, the pictures, the sounds and the words) of the learners. This also has the capacity of leading to an engaging learning environment that allows for seeing, hearing and doing (Mayer, 2001).

Similarly Kim (2003) argued that, ICT has four main functional components: information collection, information processing, information communication and information utilization. These components together have the potential of transforming learning styles of young students from traditional teacher-centered lectures to technology based student-centered activities. It does so by offering better ways of improving information use on reasoning skills, higher order thinking skills, creativity skills, communication skills and problem-solving skills, which are all skills necessary for mathematics learning (Shaikh & Khoja, 2011). However, other scholars consider the benefits of ICT in adolescent education as the "effects with" versus the "effect of" technology, which refer to short-term and long-term effects of using ICT, as show in the next section.

2.7. The Effects "with" versus "of" Computer Technology

In education, the term effect usually connotes some cognitive change as a consequence of exposure to or interaction with some stimuli (Jonassen, 2000). Today, with the proliferation of computers within the students' milieu, both in and out of school, a crucial question to be answered is, what cognitive effects do these computers have on students' minds? When students manipulate and interact with ICT, what kind of thinking and learning occurs? Empirical attempts to answer this question have reported mixed results. In order to make sense of this question, one must distinguish between the two ways in which intelligent systems (ICTs) might have an impact on the search processes of the human mind. One way is by change of performance that people show when exposed to a computer, for instance, what effect on what students do, how well they do it, and when it is done. Such potential effects are referred to as the effects withtechnology (Pea, 1985). Another way computer might impact learning is by the relatively lasting changes in students' cognitive capacities as a consequence of interaction with an intelligent system. These categories of impacts pertain to subsequent change in mastery of knowledge, skill, or deeper understanding even after the students are away from the computer and are referred to as the effects of the technology (Mandinach, 1989).

The two aspects of effects (with a computer and of [resulting from] a computer) are often presented as mutually exclusive. The cognitive residue of any information technology (the effects of computer) largely depends on how computer is used, what new opportunities the computer affords, and which of these are actually taken by the user – the effects with computer (Perkins, 1985; Olson, 1986; Pea, 1987). Apart from the effectswith and effectsof computers in education, other stream of investigation focus attention in examiningthe role ICT (computers) play on the user's minds during the thinking process. The next section will present a description of computer as a cognitive associate, i.e. the symbiotic relationship between human cognitive processes and the digital processes of the computer.

2.8. Computers as Cognitive Tools

A collection of previous studies on the use of computers as a cognitive tool has evolved over the past two decades. The terms cognitive tools and mind tools have been used interchangeably, referring to technologies that help students to actively engage in an academic activity, and facilitate cognitive processing which leads to knowledge construction. Jonassen, Peck and Wilson (2000) stated that the tools of technology are of cognitive nature rather than physical and are being used as engagers and facilitators of knowledge creation. Also, according to Jonassen and Reeves (1996), technology tools enhance the cognitive powers of human beings, and extend their cognitive functionalities during a critical thinking process, problem solving and active learning situations. Therefore, computers have the potentials toengage and facilitate critical thinking skills of learners.

Jonassen's (2000) argument is that human learning is an active mindful and constructive activity, which involves deliberate cognitive effort. In the event of using computer as a cognitive tool, the student and the computer become intellectual partners in the learning process (Kozma, 1987; Marra, 2003). Students can be able to extend their cognitive capabilities such as memory, thinking, and problem solving skills as well as transfer some of the low level tasks e.g. calculations, storage and information retrieval on to the computer systems (Salonmon, Perkins, & Globerson, 1991). These are necessary supports that allow the students to think in a more productive way and engage in key steps of articulation and reflection, which are the fundamentals of higher order thinking skills and knowledge construction. Therefore, effective use of cognitive tools should lead to active engagement, deeper thinking, and well-rounded articulation of knowledge: knowledge construction and not reproduction; conversation and not reception; articulation and not repetition; collaborationand not competition; and reflection and not prescription (Jonassen, Howland, Moore, and Marra, 2003).

According to the works of Vygotsky (1978), learning requires two mediational means tangible (technical) tools and intangible or sign (semiotic) tools to mediate and extend our ability to interact with each other. This mediational means makes it possible to eternalize our thinking into forms that we can share with others or even act upon. It is worth noting that, though students enter a joint business (intellectual partnership) with the computer, the role of the computer as a cognitive tool is only to facilitate the thinking process and not to, and will never be doing the thinking for students.

According to Lajoie, (1993), the important aspects of cognitive tools in learning are related to the supporting cognitive processes including memory organization and metacognitive processes. These tools share cognitive load by providing support for low-level cognitive skills so that the human memory is reserved for higher order thinking skills; allowing learners to engage in cognitive activities that would be out of their reach otherwise. They also allow learners to generate and test hypotheses in the context of problem solving.

Jonessen and Reeves (1996) summarized the benefits of cognitive tools as great, simple to use technological opportunities that facilitate the development of deeper and broader knowledge structure in a constructivist learning setting. It enables students access and assess information through comparing and analyzing it, which allows them to take on the ownership of their learning. Jonessen and Reeves (1996) also state that cognitive tools offload basic cognitive demands while students focus on higher cognitive processes as they explore, test, and validate their conceptions.

Usingtheories on ICT in education as a theoretical framework, different researchers have conducted multiple studies in an effort to better explain the relationship between ICT availability and use at home and at school and mathematics literacy in school subjects such as mathematics. The next section looks at prior studies that examined the relationship between ICT use and students' mathematics literacy.

2.9. Previous Studies on the Relationship between ICT Use and Students' Mathematics literacy

For the past two decades, a stream of investigations has been going on to determine the type of relationship between ICT-related factors, as an educational input at school and at home, and the academic consequences on students' test scores across various disciplines. Thus, there is a considerable body of literature on the relationship between students' ICT use both at home and at school and their educational outcomes. Unfortunately, results from these studies have reported mixed effects of ICT use on students' literacy in subject such as mathematics. While some findings indicate a positive effect of ICT use on students' mathematics literacy, other results seems to find very little or no sizeable effect on students' mathematics literacy as a result of ICT ownership and use.

Studies such as those conducted by Attewell and Battle (1999), Clotfelter, Helen, and Vigdor (2008), Jackson, Von Eye and Biocca (2003), Jackson, Von Eye and Biocca (2006a), Lenhart, Rainie, and Lewis (2001), Marshall (2002), Notten and Kraaykamp

(2009), Papanastasiou and Ferdig (2006), and Wenglinsky (2006) found a positive and significant relationship between students' use of ICT and mathematics literacy. Still in the same line of study, Livingstone, Bober, and Ellen (2005), Livingstone and Bovill (2001), Valentine and Pattie (2005) also noticed a positively significant correlation of students' computer use on their literacy level across a variety of disciplines in schools in the United Kingdom. Other sources of evidence supporting the advantage of ICT use in improving mathematics literacy includes the OCED reports of 2005 on the analysis of PISA 2003 data, the works of Gil-Flores (2009) using secondary school dataset from Spain, and the research conducted by Fiorini (2010) with data extracted from the five-year and seven-year-old school children waves of the Longitudinal Study of Australian Children (LSAC).

By analyzing the data on Czech Republic of PISA 2006, Kim, Kraemer and Yarish, (2008) and Kubiatko and Vlckova (2010) separately showed that 15-year-old students who use ICT tools in learning mathematics and science achieved higher scores on the test than their counterparts who do not employ the same ICT opportunities in their learning process. Also, according to Papanastasiou, Zembylas and Vrasidas (2003) and Wenglingsky (1998), when students utilize ICT in learning, it enhances the process and help in creating a better and easy learning environment. This can be argued from the fact that some technological software provides students with wonderful learning opportunities as well as direct personal feedback on their progress.

Nevertheless, the results of other studies are completelycontroversial. Some research have indicated a negative or an insignificant association between ICT use and mathematics literacy of young students. For example, Clotfelter (2008) was unable to find a positive effect of the use of home computer on students' literacy in mathematics and reading. Also, Livingstone and Bovill (2001) reported a negative but significant association between students' ICT use in social networking, such as the use of chat rooms and their reading and mathematics literacy scores. These results are consistent with Johnson (2006)'s findings on the negative impact of ICT use for online messaging by young students on their academic outcome in school.

In 2008, Wittwer and Senkbeil conducted a correlational study using students' PISA 2003 data from Germany to determine the impact of ICT accessibility on students' mathematics literacy score. Their study found no connection between home computer accessibility and mathematics literacy and an insignificant relationship between home computer use and mathematics literacy (Wittwer & Senkbeil, 2008). According to Wittwer and Senkbeil (2008), ICT use for social networking by students was associated with lower memory and less problem solving skills, since the short hand language used in these media usually replaces the formal method of written communication.

In another study, Gross (2004) concluded that computer with an Internet connection was negatively related to students' literacy in school. Gross argued that a convenient access to online chatting for school children was a good source of learning distraction, especially to those children struggling to complete their school assignments. Similarly, Sivin-Kachala and Bialo (2000) conducted a survey studies on students' ICT use and literacy level in different school subjects.They recorded low literacy scores across many subjects including mathematics with students using technology in learning.

2.10. ICT Use for Entertainment and Educational Outcome

Jehanzeb and Zhang (2013) carry on a careful review of the vast body of literature that has emerged on ICT use in adolescent education. They discovered that ICT use in learningcan be classified into two distinct categories: ICT use for non-educational purposes (entertainment) and ICT use for educational purposes (study). For example, using ICT to communicate and chat with friends and family relatives or watching movies and playing computer games fall under the non-academic use of ICT.Whereas using computer software such as spreadsheets, geometric software and so on, as a support tool for accomplishing specific school related task or searching the Internet for finding relevant information related to schoolwork falls under the educational use category (Jehanzeb & Zhang, 2013). They further argued that although ICT can be used in a variety of ways by school children, not all of these ways contribute to improvedmathematics literacy. If students choose to spend studying time for online chatting with peers, playing games and watching movies, a more likely effect on their mathematics literacy would perhaps be negative.

However, it has been noticed that the effect of the use of a particular ICT in learning is not similar across all subject areas. For example, Kebritchi (2008) reported that integrating educational games in the school curriculum had a significant and positive effect on students' literacy in Mathematics. Similarly, Johnson (2006) showed from a survey study that playing computer games designed strictly for the purpose of entertainment and relaxation with no learning consideration could still significantly promote students' schooling performance, especially in subject area like mathematics. Still in the same vein, Dumais (2009) conducted a study on the relationship between computer use for fun by adolescents and their grade point average (GPA) in mathematics. He concluded that students' use of computer for fun was positively correlated with mathematics literacy. These resultsare in support of the works of Dukin and Barber (2002) who argued that in general a positive relationship exists between adolescent learning and computer gaming.

However, these seem contradictory to Becker's report of 2000, in which she claimed that, over use of computers has a negative effect on student learning, especially when they use computers to play games and watch movies (Becker, 2000). Becker's claim was in accordance with the findings of Wiebe and Martin (1994), who documented a negative association between educational games integration into the curriculum and students' geography test scores (Wiebe & Martin, 1994).

2.11. Frequency of ICT Use and Mathematics literacy

Studies such as Papanastasiou, Zembylas and Ferdig (2002), Papanastasiou and Ferdig (2003), Şahinkayası (2008), and Wittwer and Senkbeil (2008), independently reported a negative or insignificant association between frequency of ICT use and students' literacyin school subjects such as mathematics. Papanastasiou, Zembylas and Vrasidas (2003), concluded that there was an insignificant relationship between the frequency of computer use and students' literacy in science and mathematics as projected by PISA 2003 results. They also reported a negative relationship between educational software use and literacy scores in science and mathematics among USA students (Papanastasiou, Zembylas and Vrasidas, 2003). Another study, using Trends in International Mathematics and Science Study (TIMSS) 1995 dataset reveals that a negative association exists between students' mathematics performance in Cyprus, Hong Kong and USA and frequent computer use in classroom (Robitaille, 1998).

On the other hand, Demir and Kılıç (2010) used a national representative sample of 3,326 students from some 157 schools in Turkey and analyze the data showing that computer use positively correlates with literacyin school mathematics. Fuchs and Woesemann (2005) conducted an interesting study using multivariate regression analysis to examine students' data drawn from the PISA 2000 database, while controlling for family background characteristics. These authors investigated the impact of ICT familiarity variables (accessibility point, purpose of use and frequency of use) on 15-year-old students' mathematics literacy on the PISA assessment. They concluded that the relationship between school computer accessibility and literacy scores in mathematics as well as in reading was insignificant but the relationship between home computer accessibility and literacy scores in mathematics as well as in reading was positive.

These results were closely similar to the OCED's report of 2005 that analyzed PISA 2003 data and found the following results. Students who use computer and Internet moderately (a few times a week), performed better in mathematics test, those students who never use computer or Internet achieved lower performance scores meanwhile, those students who use computer and Internet intensively (several times a week) obtained the worst results in mathematics literacy (OCED, 2005).

2.12. Students' Use of Software and Mathematics literacy

According to Lei (2010), the impact of using a specific computer software program is directly linked to the educational outcome associated to that particular program. Working with 538 secondary school students in the USA, Lei (2010) showed that student's use of word possessor to edit an assignment paper and the use of paint program in modifying a graphic file for a school project was positively related to high literacy scores. Also, Mendicino, Razzaq and Hefferman (2009) analyzed the impact of web-based exploration by 8th graders for mathematics assignment on their mathematics literacy. They arrived at the conclusion that there was a significant improvement in mathematics literacy with those students who used a web-based tool for doing the mathematics homework against their counterparts who used the traditional paper-based approach. Means and Olson (1994) stated that multimedia software could connect the classroom learning to real life situations and thus enhance students' learning. Nevertheless, Papanastasiou and Ferdig (2003) reported a negative relationship between educational software use and literacy scores in science and mathematics among USA students.

2.13. ICT Use at Home and ICT Use at School and Mathematics literacy

Some researcher think that the location where ICT is used for learning greatly determines impact of learning outcome, as such, they focus attention on ICT use at home and ICT use at school, yet reported mixed results too. Studies on ICT use at home and ICT use at school yielded different learning outcomes, with a slight positive favor for ICT use at home. Generally, most studies that employ data from the PISA database have reported a non-significant or negative effect on the relationship between school use of ICT (computer, software & Internet) and students' literacy scores. For example, Fuchs and Woesemann (2005) reported that the relationship between school ICT use and literacy scores in reading andmathematics was insignificant and negative respectively. On the contrary, other studies reveal a positive impact of ICT use at home and students' literacy scores on the PISA tests (Klutting, 2009; Ponzo 2011). Du, Havard, Yu, and Adams (2004) conducted a study using 10th graders' data in the United States from the Educational Longitudinal Study (ELS) 2002 dataset to investigate the effects of home computer use and students'literacy rate. They arrived at the conclusion that there was a positive effect of home computer use on the composite performance scores in reading and mathematics (Du et al., 2004). Still in the same investigation pathway, Papanastasiou and Ferdid (2006) reported a positively significant relationship between home computer use and mathematics literacy, after analyzing the U.S. data of PISA 2006.

In summary, although there is huge body of literature on the relationship between ICT availability and use at home and at school and students' mathematics literacy across different disciplines, it is still difficult to conclude on the effect of ICT on student' literacy because the results of these studies are inconsistent. Some results indicate a positive effect of ICT use on students' mathematics literacy, others seems to find very little or no sizeable effect on students’ mathematics literacyas a result of ICT possession and use. Therefore, this study willuse PISA 2012 data to continue investigation on the relationship between availability and use of ICT, at home and at school and 15-year-old students’ mathematics literacy. It will also examine the relationship between students’ ESCS and their mathematics literacy level, using a Multiple Linear Regression models.

3. SIGNIFICANCE OF THE STUDY

This study explores the availability and use of ICT, both at home and at school,and their relationship with 15-year-old students' mathematics literacy using PISA 2012 data, hoping that the results from the findings will be beneficial in the following ways: Firstly, policymakers, educational system, and parents will be able to understand what works well and what does not, with ICTs in enhancing student learning. It would reveal useful information to governments and parents who spend huge budget on students ICT equipment and to teachers who strive to incorporate ICT tools in teaching whether, the academic returns significantly reflect the investments. Secondly, it may contribute an insightful understanding on the impact of ICT availability and use and students' literacy in mathematics. Lastly, parents may be informed of what specific role ICTs play in their children' learning and what component(s) of ICT is/are most impactful in the learning of school mathematics.

4. STATEMENT OF THE PROBLEM

Compared to a few decades ago, nowadays computers and Internet have tremendously reshaped teaching and learning practices within school environments at an international level. Students and teachers encounter ICT at home and at school: governments worldwide are constantly faced with the challenges of equipping schools with both human and material ICT resources. Parents on their part are not left out, as they keep struggling with efforts to build a modern ICT-friendly learning environment for their children at home. Upon all these investment of ICT in education, previous studies have failed to provide clear and consistent evidence on the benefits of such ICT use on students' mathematics literacy.

Considering the fact that governments spend a sizeable amount of the national budget on different kinds of school ICTs and parents spend reasonable amount of family income to provide a technology-rich learning environment to their children at home. Also nowadays, almost every teacher is struggling with efforts to incorporate ICT into their lesson and students worldwide are in constant use ICT as a habit of life, it is worth investigating through this study, whether all these forms of investments on students' ICT tools as an educational input yield the desired learning outcome. Thus, the next section is aim to provide information on the purpose of this study.

4.1. Purpose of Study

This study aims to investigate whether the availability and use of ICT, at home and at school is associated with 15-year-old students' mathematics literacy, using PISA 2012 data. It also aims at examining the relationship between students' economic, social and cultural status (ESCS) and their mathematics literacy level, as well as the relationship between ESCS and ICT availability and use. The data for this study was extracted from the student-level dataset of PISA 2012. However, only 37 of the 65 countries and economies that participated in the PISA 2012 completed the questionnaire on ICT familiarity. Therefore only data from each of the 37 countries and economies shown in Table 1were analyzed to empirically determine which variables predict students' literacy level in

Mathematics. The statistical analyses include multiple linear regressions to determine the commonality and differences among the 37 countries, in terms of the strength of the regression coefficients of the ICT availability and use variables.

It is Important to note that PISA refers to all participating education systems as countries and economics because some economies such as Macao, Taipei, Hong Kong and Shanghai within China and Massachusetts, Connecticut and Florida in the United States participate in the PISA as separate entities.

Table 4.1. Countries and economies with available data on ICT familiarity and students' ESCS in the PISA 2012 results

Country or Economy with available Data					
Country/Economy		**Code**	**Country/Economy**		**Code**
1	Austria	AUS	20	Liechtenstein	LIE
2	Australia	AUT	21	Latvia	LVA
3	Belgium	BEL	22	Macao China	MAC
4	Switzerland	CHE	23	Netherland	NLD
5	Chile	CHL	24	Norway	NOR
6	Costal Rica	CRI	25	New Zealand	NZL
7	Czech Republic	CZE	26	Poland	POL
8	Germany	DEU	27	Portugal	PRT
9	Estonia	EST	28	China Shanghai	QCN
10	Finland	FIN	29	Perm Russian Federation	QRS
11	Greece	GRC	30	Russian Federation	RUS
12	Hong Kong China	HKG	31	Singapore	SGP
13	Croatia	HRV	32	Serbia	SRB
14	Hungary	HUN	33	Slovak Republic	SVK
15	Ireland	IRL	34	Slovenia	SVN
16	Iceland	ISL	35	Sweden	SWE
17	Jordan	JOR	36	China Taipei	TAP
18	Japan	JPN	37	Turkey	TUR
19	Korea	KOR			

4.2. Research Questions

In order to contribute to the understanding of the association between ICT availability and use and mathematics literacy using PISA 2012 results, the dataset was analyzed with the following research questions:

i. To what extent do ESCS and ICT related variables in PISA2012 predict mathematics literacy in each of the 37 countries?

ii. What are the commonalities and differences among the countries in terms of the strengths of the regression coefficients?

4.3.1. Operational Definitions

In this study, mathematics literacy, which is the criterion variable, ICT familiarities variables and ESCS - the predictor variables, are operational defined as follows:

4.3.1.1. Student's Mathematics Literacy. This is the criterion variable or dependent variable. It refers to 15-year-old students' capacity to reason mathematically and employ mathematical concepts, facts, procedures and tools to describe, explain and predict phenomenon in a variety of contexts. Therefore, students score on the PISA mathematics test items measures their mathematics literacy (OCED, 2013).

4.3.1.2. Availability of ICT at Home (ICTHOME). One of the predictor variables, it refers to the degree to which 15-year-olds had ICT devices at their disposal for use at home. Therefore, the points students score on ICTHOME index derived from the relevant student questionnaire items on PISA 2012 measures this predictor variable (OCED, 2013).

4.3.1.3. Availability of ICT at School (ICTSCH). One of the predictor variables, it refers to the extent to which 15-year-olds had ICT devices at their disposal for use at school. Therefore, the points students score on ICTSCH index derived from the relevant student questionnaire items on PISA 2012 measures this predictor variable (OCED, 2013).

4.3.1.4. ICT Use at School (USESCH). One of the predictor variables, it refers to the frequency to which 15-year-olds utilized ICT devices at school. Therefore, the points students score on USESCH index derived from the relevant student questionnaire items on PISA 2012 measures this predictor variable (OCED, 2013).

4.3.1.5. ICT Use Outside School or Home (USEHOME). One of the predictor variables, it refers to the frequency to which 15-year-olds utilized ICT devices at home. Therefore, the points students score on USEHOME index derived from the relevant student questionnaire items on PISA 2012 measures this predictor variable (OCED, 2013).

4.3.1.6. ICT Use for Mathematics (USEMATH). One of the predictor variables, it refers to the purpose for which 15-year old students use a computer in a mathematics lesson. Therefore, the points students score on USEMATH index derived from the relevant student questionnaire items on PISA 2012 measures this predictor variable (OCED, 2013).

4.3.1.7. Students' Economic Social and Cultural Status (ESCS). As the final predictor variable, it refers to an index derived from the students' family background: highest occupational status of parents, highest level of parental education, i.e. number of years of formal education and number of home possessions such as number of books at home. Therefore, the points students score on the relevant student questionnaire items on PISA 2012 measures this predictor variable (OCED, 2013).

5. METHODOLOGY

This section describes the PISA survey design, the development of the mathematics test items and the ICT familiarity questionnaires that were used in the PISA 2012 assessment. It also provides key information on the Multiple Linear Regression (MLR) analysis technique that has been used to explore the dataset.

5.1. PISA Design

The mathematics test content and arrangement in the test booklets (paper-based), was clearly specified in the test manual adopted for PISA 2012. The specification ensured effective development of a group of test items (item clusters) and the precise testing time. The standard main test items were complied in seven mathematics clusters including old clusters from previous test and each cluster requires half an hour (30minutes) of testing time. These items were arranged and presented to students in 13 standard test booklets, with each containing four clusters to be tested for two hours (OCED, 2013). The reason of including old clusters from previous PISA test was to facilitate the connection of ability estimate across survey administration. As in previous PISA survey, the cluster rotation design for the standard booklets in the main assessment was done to capture a larger volume of test items (OECD, 2013).

It is important to mention that, a special one-hour booklet was available, in addition to the thirteen regular two hours booklets and this special booklet was prepared in consideration for those schools with special need students. The items contained in the special booklet were half as many as the items found in the normal booklets (OECD, 2013). In each participating country or economy, one of the thirteen test booklets was randomly distributed and administered to each qualified 15-year-old student and during the test taking exercise, a short break of five minutes is interspersed midway. Throughout the test, student used pencils, erasers, rulers and computing machines as was deem necessary (OECD, 2013).

5.2. Development of PISA 2012 Mathematics Test Items

In October 2009, a meeting of over 80 mathematicians, mathematics educators and test developers from 34 participating countries held to review, revise and modify the existing draft mathematics framework for PISA 2012 content development. This documentation framework is to guide all parts of the development process of cognitive items, which involves the calling for submission, carrying out cognitive laboratory activities, writing and reviewing of test items from all participating countries(OECD, 2013). After series of considerations, multiple pilot tests are conducted and an extensive field trial also done. Later a final version is adopted and an external validation of the item pool is implemented. The final mathematics framework for PISA 2012 with a good number of examples prepared and made public both in French and English (OECD, 2013)

5.3. PISA Sampling

One of the principal criteria for selecting participants to take the PISA test is the student's ages. Only students whose ages range from 15years 6 months to 16years 2 months and are currently enrolled either in a full-time or part-time, public or private, academic or vocational learning institution are eligible for participation. The reason for choosing only this age range is that school children of this age group in most OECD member countries come to towards the end of their compulsory secondary education. At this stage, there is an expected package of knowledge, skills and attitude assumed to have gained by the students within this first decade of their formal schooling (OECD, 2013).

Specifically, PISA 2012 employs a two-stage stratification sampling technique for selecting participants within the qualified schools in each country. A systematic sampling of schools with the criteria of students is done and then, a random selection of thirty-five 15-year-old students within each school is conducted (OECD, 2013). However, certain students could be exempted from participating on the PISA test, once it is evidenced that, the students are intellectual disabled as confirmed by experts; or that the students are physical disabled as indicated by the school authorities; or the students are proficiency inadequate of the language used in the PISA assessments. Similarly, certain schools could be refused participation if the following conditions are evident. When accessibility and feasibility of a school becomes an obstacle for the smooth administration of the PISA exam or when students of theschool are mentally disabled and/or physically disabled or language restricted (OECD, 2013).

5.4. PISA 2012 Participants

In PISA 2012, the sample size of 15-year-old students who completed the standardized test from all 65 participated countries and economies was 510,000 students. This figure represented the target population of about 28 million students between the ages of 15 years 3 months and 16 years 2 months and also represents more than 80% of the world economy (OCED, 2013). For the 37 countries and economies considered in this study, the sample size was 217,152 (OCED, 2013). Table 3.1. shows the total number of 15-year-old students from each of the 37 countries or economies.

PISA data are weighted to compensate for the variation probabilities that might result from sampling bias (OECD, 2013). Data weighting is usually done when the researcher recognizes and acknowledges that some observations within a sampling set are more important that others and definitely, will have to contribute more than others for a particular population estimate. Of course in practice, schools differ in student size, with most often a larger enrolment in urban localities and smaller enrolment in rural areas; thus if a simple random sampling is used for selecting students, there would be no impact on school selection probability but a severe impact will occur in the student selection probability. Since it would properly underestimate the student population size and will result in variability of final student weight, which increases the sampling variance as well. Therefore, within a given sampling set, an observation with a very small chance of selection will be considered as more important than a sampling unit with a high probability of selection, which means, weighting is an inversely proportionality to probability of selection. With this method of school and students sampling, the probability of a school to be selected is equal to the ratio of the school size multiples by the number of schools to be sampled and divided by the total number of students in the population (OECD, 2013).

Table 5.1. Number of participating 15-year-old students from the selected 37 countries and economies

Population and sample information					
OECD	Total population of 15-year-olds	Total in national desired target population	Number of participating students	Number of excluded students	Overall exclusion rate (%)
Australia	291 967	288 159	17 774	505	4.00
Austria	93 537	89 073	4 756	46	1.33
Belgium	123 469	121 209	9 690	39	1.40
Chile	274 803	252 625	6 857	18	1.30
Czech Republic	96 946	93 214	6 535	15	1.83
Estonia	12 649	12 438	5 867	143	5.80
Finland	62 523	62 195	8 829	225	1.91
Germany	798 136	798 136	5 001	8	1.54
Greece	110 521	105 096	5 125	136	3.60
Hungary	111 761	108 816	4 810	27	2.58
Iceland	4 505	4 491	3 508	155	3.81
Ireland	59 296	57 952	5 016	271	4.47
Japan	1 241 786	1 214 756	6 351	0	2.15
Korea	687 104	672 101	5 033	17	0.82
Netherlands	194 000	193 190	4 460	27	4.42
New Zealand	60 940	59 118	5 248	255	4.61
Norway	64 917	64 777	4 686	278	6.11
Poland	425 597	410 700	5 662	212	4.59
Portugal	108 728	127 537	5 722	124	1.60
Slovak Republic	59 723	59 367	5 737	29	2.93
Slovenia	19 471	18 935	7 229	84	1.58
Sweden	102 087	102 027	4 739	201	5.44
Switzerland	87 200	85 239	11 234	256	4.22
Turkey	1 266 638	965 736	4 848	21	1.49
Costa Rica	81 489	64 326	4 602	2	0.03
Croatia	48 155	46 550	6 153	91	2.24
Hong Kong-China	84 200	77 864	4 670	38	1.76
Jordan	129 492	125 333	7 038	19	0.39
Latvia	18 789	18 375	5 276	14	4.02
Liechtenstein	417	383	293	13	4.22
Macao-China	6 600	5 416	5 335	3	0.17
Russian Federation	1 272 632	1 268 814	6 418	69	2.40
Serbia	80 089	74 272	4 684	10	2.87
Shanghai-China	108 056	90 796	6 374	8	1.50
Singapore	53 637	52 163	5 546	33	1.17
Chinese Taipei	328 356	328 336	6 046	44	1.22

5.5. PISA Test Administration Procedure

All the schools that participated in the PISA 2012 did so through the supervision of an appointed school coordinator. The task of the school coordinator was to compile the list of all eligible 15-year-old students in the school and transmit them to the PISA National Centre in each participating country or economy, where a random selection of 35 students to take part in the PISA test was done. The selected students together with their parents are contacted to obtain all necessary permission by the school coordinator before students participate on the test (OCED, 2013).

On the test day, a trained and employed test administrator from the PISA National Centre usually conduct the test sessions. In practice, the test administrator and the test coordinator plan and schedule for a smooth administration of the test. Of course, this must be in accordance with the prescribed conduct of the examination. It is the duty of the test coordinator to ensure that all the eligible students from different grade levels and classes attend the test under identical conditions. Meanwhile, the test administrator on his /her part guarantees that each set of test booklet is properly distributed to the right group of students and officially introduce the test to the students as stipulated by PISA rules and regulations. This introduction is a prescribed documentation to all test administrators to ensure that all students in different schools and countries were receiving exactly the same information patenting to the test (OCED, 2013).

At the beginning of the test session, students usually start with some practice items found in the test booklet, before beginning the test proper. This is usually to get the students ready for the assessment exercise. The entire testing session is separated into two section: the first part is a two-hour test session that measures the students' knowledge and skills in the specific domain of test and the other part is a 30-minute questionnaire session that gather information about students' personal background and ICT-related features. Normally, the test sessions are interspersed with two short-breaks, one at mid-way in the first session and the other at the end of the first session (OCED, 2013).

5.6. Measures

The 2012 PISA's large-scale assessment is not limited to assessing only the mathematics, science, and reading literacies of 15-year-old students in different grade levels. In addition, the survey also gathers information about students' characteristics - information about students' family background, ICT- related characteristics and school characteristics. Therefore, the PISA assessment scale provides substantial information on students' mathematics literacy scores (the criterion variable) and ICT-related variables (ICT availability at home [ICTHOME], ICT availability at school [ICTSCH], ICT use at home [USEHOME], ICT use at school [USESCH], ICT use for Mathematics lessons [USEMATH] and Student's Economic Social and Cultural Status [ESCS]). The availability of these dataset enables this study to extract relevant information to explore the relationship between ICT use and students' mathematics literacy.

The reason for choosing these variables lies in their very interference nature in the students' daily lives. For example, mathematics literacy is associated with students' ability to formulate and solve mathematical problems in real life situations. It constitutes key knowledge and skills, crucial for sound reasoning and proper decision making in order to accomplish success in personal, civic and professional life. Therefore a measure of students' mathematics literacy would indicate the level of preparedness for meaningful and successful participation in an ever-increasing knowledge base society. Similarly, ICT-related variables were selected because of the high prevalence rate of ICT tools among 15-year-old students nowadays. According to Kate McKenzie, " ICT in education is the key to unlock the skills and knowledge of our future generation of young people. It is the tool for learning for the 21st century" (Kate, 2013). Lastly, Student's Socio-economic status was considered to have a significant influence on ICT possession.

5.7. Mathematics Literacy

In the PISA 2012, mathematics literacy was for second time in focus as the major domain of assessment while Reading and Science were tested as minor domain. According to OECD's definition of mathematics literacy, " Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assist individual to recognize the role that mathematics plays in the world and to make a well founded judgments and decisions needed by constructive, engaged and reflective citizens" (OECD, 2013, p. 25).

The PISA 2012 mathematics items for the paper-based test comprise 56 units, which contained a total of 110 cognitive items. Students responded to the cognitive items either with selected or constructed responses. In the selected response case, students were required to select the best option from a multiple-choice with 4, or in some cases, 5 response options. For the constructed response items, students were expected to construct a numeric response within a very limited constraint, or only required a word or a short phrase as an answer (OECD, 2013). The PISA mathematical literacy test seek to measure in terms of students' mathematics score on PISA test, the extent to which 15-year-old students are able to apply their mathematical knowledge and skills learned through formal schooling in a variety of real-life situation. Therefore, high score on PISA scaling infer students' readiness to face real-life challenges in future life.

5.8. ICT Familiarity Questionnaire

The ICT familiarity questionnaire involved items in the following domain; ICT availability, general computer use, ICT use out of school, ICT use at school, and attitude toward computer. Items were arranged on a Likert-type scale and administered to students after the international student questionnaire. This took about five minutes to complete.

It is important to note that not all the variables contained in the ICT familiarity questionnaire were included for this study. Only ICT variables that were consider crucial in answering the research questions and whose data were available in PISA 2012 dataset were included. For complete information on the ICT familiarity questionnaire, see Appendix A.

5.8.1. ICT Availability at Home (ICTHOME)

The availability of ICT at home (ICTHOME) refers to the degree to which 15-year-olds had ICT devices at their disposal for use at home. The ICT availability questionnaire contained 11 items that asked if students had the following ICT tools at home for use; a desktop computer, portable computer, tablet computer, Internet connection, video games console, cell phone with Internet access, cell phone with no Internet access, portable music player, printer, USB stick, and eBook reader. In response, students answered these items by ticking on one of the following three options: (1) Yes, and I use it, (2) Yes, but I don't use it, and (3) No (OECD, 2013).

5.8.2. ICT Availability at School (ICTSCH)

The availability of ICT at home (ICTSCH) refers to the degree to which 15-year-olds had ICT devices at their disposal for use at school. The ICT availability questionnaire contained 7 items that asked if students had the following ICT tools at school for use; a desktop computer, portable computer or notebook, tablet computer (e.g. ipad), Internet connection, printer, USB stick, and eBook reader. In response, students answered these items by ticking on one of the following three options: (1) Yes, and I use it, (2) Yes, but I don't use it, and (3) No (OECD, 2013).

5.8.3. ICT Use at School (USESCH)

ICT use at school (ICTSCH) refers to the frequency to which 15-year-olds utilized ICT devices at school. The ICT school use questionnaire contained 9 items that asked students how often they use the computer at school for the following activities; chatting online, using email, browsing the Internet for schoolwork, downloading or uploading material from the school website, posting work on the school website, playing simulations, practicing and drill such as for mathematics, doing home work on school computer, using school computer for group work and communication with other students. In return, students responded to these items by checking on one of the following three options: (1) Yes, and I use it, (2) Yes, but I don't use it, and (3) No (OECD, 2013).

5.8.4. ICT Use out of School or Home (USEHOME)

ICT use outside school or home (USEHOME) refers to the frequency to which 15-year-olds utilized ICT devices at home. The ICT home use questionnaire contained 17 items that asked students how often they use the computer at home for the following activities; browsing the Internet for schoolwork, using email for communicating with other students about schoolwork, using email for communicating with teachers and submission of homework or other schoolwork, downloading or uploading materials such as course material, checking the school's website for announcements like teacher's absence, doing homework on the computer, sharing school related materials with others, playing one-player games, playing collaborative online games, using email, chatting online, participating in social networking such Facebook, browsing the Internet for fun such YouTube, reading online news, obtaining practical information from the Internet, downloading films, games, music or software from the Internet, uploading your created contents for sharing. In response, students responded to these items by checking on one of the following three options: (1) Yes, and I use it, (2) Yes, but I don't use it, and (3) No (OECD, 2013).

5.8.5. ICT Use for Mathematics (USEMATH)

ICT use for mathematics (USEMATH) refers to the purpose for which 15-year old students use a computer in a mathematics lesson. The questionnaires for ICT use for mathematics lessons comprised of 7 items that asked students if within the last month, has a computer ever been used for the following purpose in mathematics lessons? Drawing the graphs of functions like $y=5x+2$; calculating with numbers such as 3*462/6; constructing geometric figures, such as triangles; entering data in spreadsheet, like in Excel; rewriting algebraic expressions and solving equations in the form of $x^2+4xy+y^2$; drawing histogram, and finding out how the graph of functions changes depending of some variables. Students had three choices to tick the one that best describe them: The three response categories were (1) Yes, Students did this, (2) Yes, but only the teacher demonstrated this, and (3) No (OECD, 2013). Table 3.2. shows the reliabilities values of the ICT index in the 37 countries and Economies.

5.9. The Students' Economic Social, and Cultural Status (ESCS)

The PISA 2012 index of Students' Economic Social, and Cultural Status (ESCS) was derived from three variables related to the students' family background: highest occupational status of parents, highest level of parental education, i.e. number of years of formal education and number of home possessions such as number of books at home. This index was derived from a principal component analysis of standardized variables, taking the factor score for the first principal component as measure of the index Students' ESCS. In order to determine the degree to which the components of this index operate in a similar manner across different countries, the same principal component analysis was ran for each of the OECD countries and partner countries. Results of the analysis showed similar pattern of the factor loading and all three components contributing at similar degree to the index.

The imputation of component of students with missing data on one component was done on the basis of a regression on the other two variables, with an additional random error component. An OCED mean of zero and a standard derivation of one were the final values on the PISA 2012 index of Students' ESCS. As an innovation with the PISA 2012 test, the rotated cluster design, which had existed with the cognitive test items, was introduced to the student questionnaires including those on Students' ESCS, so as to extend the coverage of the student questionnaire (OECD, 2013). Table 3.2. column seven shows the reliabilities values of the ESCS index in the 37 selected countries and Economies.

5.10. Reliability and Validity of PISA Results

Reliability or consistency result refers to the degree of obtaining the same results with a particular set of students each time a specific test is administered. The PISA ensures for reliability in the sense that, it administers an equivalent test material in a closely similar manner in all the participating countries and economies. So with such consistent data collection fashion coupled with the high students' participation rate, the PISA results can be compared across countries and economies (OECD, 2014).

Validity refers to the extent to which the PISA test precisely measures how capable are 15-year-old students on extrapolating applicable knowledge and skills from the curricular content to resolve challenging problems in actual life situations. The stringent quality assurance procedures employed by PISA in sampling, collecting, translating and submitting data, minimize chances for spurious variation or error. Consequently, great efforts and resources are made, in order to strike a cultural and linguistic balance in the test materials (OECD, 2009). This therefore means, the results of PISA have a high degree of reliability and validity and as such can significantly improve the understanding of factors affecting educational outputs in each participating countries and economies, in terms of the variables tested.

5.11. Data Analysis and Procedure

The statistical analyses were conducted using R version 3.1.0. The international assessment data manager package (intsvy) version 1.4 developed by Daniel Caro and Przemyslaw Biecek (2014) was used to import the raw dataset from the PISA website into R. In order to answer the research question, a linear multiple regression models was fitted to the data and the parameters of the model calculated for each of the 37 countries. To obtain reliable population estimates of the variables, the survey package for R (Lumley, 2014), which incorporates student weights and school level sampling units to account for the two-stage stratified sampling, was used. Particularly, the survey-weighted generalized linear model (svyglm) function was utilized, which models fit a generalized linear model to data from complex survey design with inverse probability weighting and design-based standard error.

Table 5.2. Reliabilities scale of selected ICT index and missing percent of data in the 37 countries and economies

Country/Economy	ICTHOME	ICTSCH	HOMESCH	USESCH	USEMATH	ESCS	MISSING PERCENT
Austria	0.44	0.60	0.82	0.81	0.87	0.93	0.052
Australia	0.53	0.40	0.87	0.78	0.89	0.94	0.031
Belgium	0.50	0.70	0.85	0.88	0.89	0.94	0.11*
Switzerland	0.45	0.66	0.83	0.85	0.89	0.92	0.038
Chile	0.68	0.65	0.83	0.84	0.91	0.91	0.03
Costal Rica	0.76	0.69	0.83	0.86	0.94	0.87	0.129*
Czech Republic	0.45	0.55	0.81	0.85	0.90	0.94	0.047
Germany	0.42	0.66	0.75	0.82	0.88	0.94	0.225*
Estonia	0.45	0.63	0.75	0.84	0.88	0.91	0.028
Finland	0.41	0.53	0.81	0.81	0.89	0.92	0.045
Greece	0.64	0.68	0.88	0.91	0.92	0.9	0.035
Hong Kong China	0.52	0.55	0.82	0.85	0.90	0.92	0.057
Croatia	0.52	0.67	0.81	0.87	0.92	0.92	0.019
Hungary	0.64	0.65	0.84	0.88	0.92	0.94	0.048
Ireland	0.50	0.67	0.80	0.81	0.91	0.92	0.026
Iceland	0.40	0.56	0.85	0.87	0.92	0.91	0.119*
Jordan	0.85	0.79	0.90	0.93	0.93	0.88	0.087
Japan	0.63	0.71	0.70	0.74	0.96	0.93	0.054
Korea	0.55	0.68	0.83	0.88	0.95	0.93	0.005
Liechtenstein	0.38	0.65	0.83	0.83	0.85	0.92	0.007
Latvia	0.57	0.67	0.82	0.89	0.92	0.91	0.017
Macao China	0.56	0.61	0.80	0.81	0.90	0.92	0.015
Netherland	0.51	0.49	0.75	0.83	0.91	0.94	0.052
Norway	0.50	0.38	0.83	0.84	0.84	0.92	0.063
New Zealand	0.60	0.52	0.88	0.83	0.91	0.93	0.055
Poland	0.59	0.68	0.80	0.89	0.92	0.93	0.021
Portugal	0.55	0.62	0.88	0.92	0.93	0.93	0.034
China Shanghai	0.65	0.70	0.81	0.82	0.91	0.92	0.005
Perm Russian Fed.	0.53	0.57	0.61	0.72	0.83	0.91	0.021
Russian Federation	0.60	0.69	0.85	0.91	0.92	0.88	0.029
Singapore	0.53	0.63	0.89	0.87	0.91	0.94	0.016
Serbia	0.70	0.74	0.85	0.89	0.93	0.92	0.048
Slovak Republic	0.61	0.66	0.84	0.87	0.92	0.94	0.037
Slovenia	0.56	0.69	0.86	0.92	0.92	0.93	0.049
Sweden	0.53	0.47	0.87	0.88	0.94	0.92	0.095
China Taipei	0.63	0.59	0.86	0.85	0.95	0.94	0.01
Turkey	0.78	0.75	0.86	0.89	0.92	0.92	0.033

Note: * = missing percent greater than 0.10

All analyses was repeated five times for each of the five plausible values and parameter estimates were averaged, following the recommendations of Rutkowski, Gonzales, Joncas, and Von Davier (2010). To deal with missing data, the pairwise deletion technique was however been used as input for a linear regression analysis (Peugh & Enders, 2004). It is important to remember that in the vast majority of cases, a key assumption of using this technique is that data is missing completely at random (MCAR)

5.12. Multiple Linear Regressions (MLR)

Linear regression is a statistical procedure for predicting the value of a dependent variable or criterion variable from an independent variable or a predictor variable when the relationship between the variables can be described with a linear model. Linear regression is performed either to predict the response variable based on the predictor variables, or to study the relationship between the response variable and predictor variables. Linear regression implements a statistical model that, when relationships between the independent variables and the dependent variable are almost linear, shows optimal results. For example, using linear regression, students' mathematics scores can be explained as a function of other academic factors such ICT use at home, ICT use at school, ICT use for mathematics learning, or economic social and cultural factors.

Linear regression is a method of estimating the conditional expected value of dependent variable of interest Y given the values of some other predictor variables X. The dependent and independent variables may be scalars or vectors.This fits a linear model of the form

$$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 +.... + \beta_k X_k + e \tag{5.1}$$

Where Y is the dependent variable (criterion), $X_1, X_2, \ldots X_k$ are the independent variables (predictors),e is random error and β_0, β_1, β_2, …β_k are known as the regression coefficients, which have to be estimated from the data. (Intersect on the y-axis). Therefore, applying the model to the variables in this study, we obtain:

$$\text{Mathematics literacy} = \beta_0 + \beta_1\,\text{ICTHOME} + \beta_2\,\text{ICTSCH} + \beta_3\,\text{USEHOME} + \beta_4\,\text{USESCH} + \beta_5\,\text{USEMATH} + \beta_6\,\text{SECS} + e \qquad (5.2)$$

The parameters of the models (βs) will be evaluated with respect to the ratio of the estimate to its standard error (t-value) from which probability values for rejecting the null hypothesis ($\beta=0$) will be calculated.

6. RESULTS AND INTERPRETATION

6.1. Findings

In this study, the statistical analysis technique chosen to analyze thedata was the Multiple Linear Regression (MLR). The data on Mathematics literacy, ICT- familiarity factors and students ESCSfrom each of the 37 selected countries and economies, were run into the MLRmodel. The remaining countries and economieswhose data for this study were missing, were excluded in the analysis. Therefore, the MLR model was used to investigate the relationships between ICT related variables, students ESCS and mathematics literacy scores of 15-year-old students using PISA 2012 results from 37 selected countries and economies. Precisely, the analysis was to find out how wellthe predictor variables: ICTHOME, ICTSCH, USEHOME, USESCH, USEMATH and ESCS could statisticallypredict the criterion variable, i.e. mathematics literacy of 15-year-old students on the PISA test.

The preceding sections present the results of the analysis under the following headings: Overall view of the results, mathematics literacy as predicted by ICT availability at home, mathematics literacy as predicted by ICT availability at school, mathematics literacy as predicted by ICT use for mathematics lessons, mathematics literacy as predicted by ICT use at home, mathematics literacy as predicted by student’s ESCS. For detail information and separate tables on each criterion variable, see Appendices B.1. to B.6.

6.2. Overall Relationships between the ICT Predictor Variables, Students’ ESCS and Mathematics Literacy

Table 6.1. presents the overall results of the MLR coefficients of each predictor variables in decreasing regression coefficients formean mathematics literacy scores. The significant status of the average mathematics literacy, denoted by an asterisk (*) is determined by the strength of the multiple linear regression coefficients. Countries are ordered by decreasing regression coefficients of average mathematics literacy scores.

Table 6.1. The association between selected ICT predictor variables, students' ESCS and mathematics literacy from a MLR analysis of PISA 2012 data.

	INTERCEPT	ICTHOME	ICTSCH	USEMATH	USESCH	USEHOME	ESCS
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
TAP	578.861*	-10.91*	2.966*	-18.07*	-6.874*	15.08*	59.423*
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
LIE	541.931*	-5.28*	-18.657*	2.344	-25.906*	2.137	32.004*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
AUT	513.586*	-18.416*	-4.139	-6.163*	-9.174*	11.331*	43.027*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.2046*
SVN	498.866*	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
NOR	498.065*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
SVK	493.0528	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.874*
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*

Note: *= statistically significant at $\alpha = 0.05$ level.

Second column in table 6.1. presents in a descending order, the regression coefficient (β_0) on the y-intercepts when all predictor variables are equal to zero. These figures indicate that the mean mathematics literacy scores for all 37 selected countries and economies were positive and significant, though with variation in regression coefficient strength. The East Asian countries; China Shanghai, Singapore, China Taipei, China Hong Kong, Macao China Japan and Korea have the highest mathematics literacyaverage score of 616.5, 584.0, 578.9, 578.4, 556.3, 549.6, and 546.4 respectively. While Jordan, Costal Rica, Chile, Serbia, Greece, Iceland and Sweden have the lowest mathematics literacy mean score of 413.9, 431.0, 443.0, 459.4, 461.4, 472.9, and 477.3 respectively. It is important to note that about 65% of all 37 countries and economies performed above the OCED average of 494 and Asian countries produced the 7-top performances.

Interpreting the tables horizontally, only eight out of the 37 selected countries (Chile, Czech Republic, Croatia, Netherlands, New Zealand, Singapore, Serbia and Slovak Republic) registered astatistically significant regression coefficient for all predictor variables, though at different level of significance and direction. Among these eight countries, Czech Republic, Serbia, Slovak Republic and Croatia are Eastern European countries, which share similarities in geographical location, system of education, linguistic and cultural values (Kjærnsli & Lie, 2004). New Zealand happened to be the lone English speaking country in this group of eight. Also, Singapore with typical Asian characteristics was isolated in this group. Netherland, the only Nordic country from the North West of Europe has distinct feature in politics, socioeconomic and historical identities (OECD,2014).

6.3. Mathematics Literacy as Predicted by ICT Availability at Home

Figure 6.1. shows the overall results of the multiple linear regression coefficients of ICTHOME in each of the 37 selected countries and economies, predicting mathematics literacy from PISA 2012 results. For a separate table ordering countries by decreasing regression coefficients of ICTHOME index, see Appendix B.1.

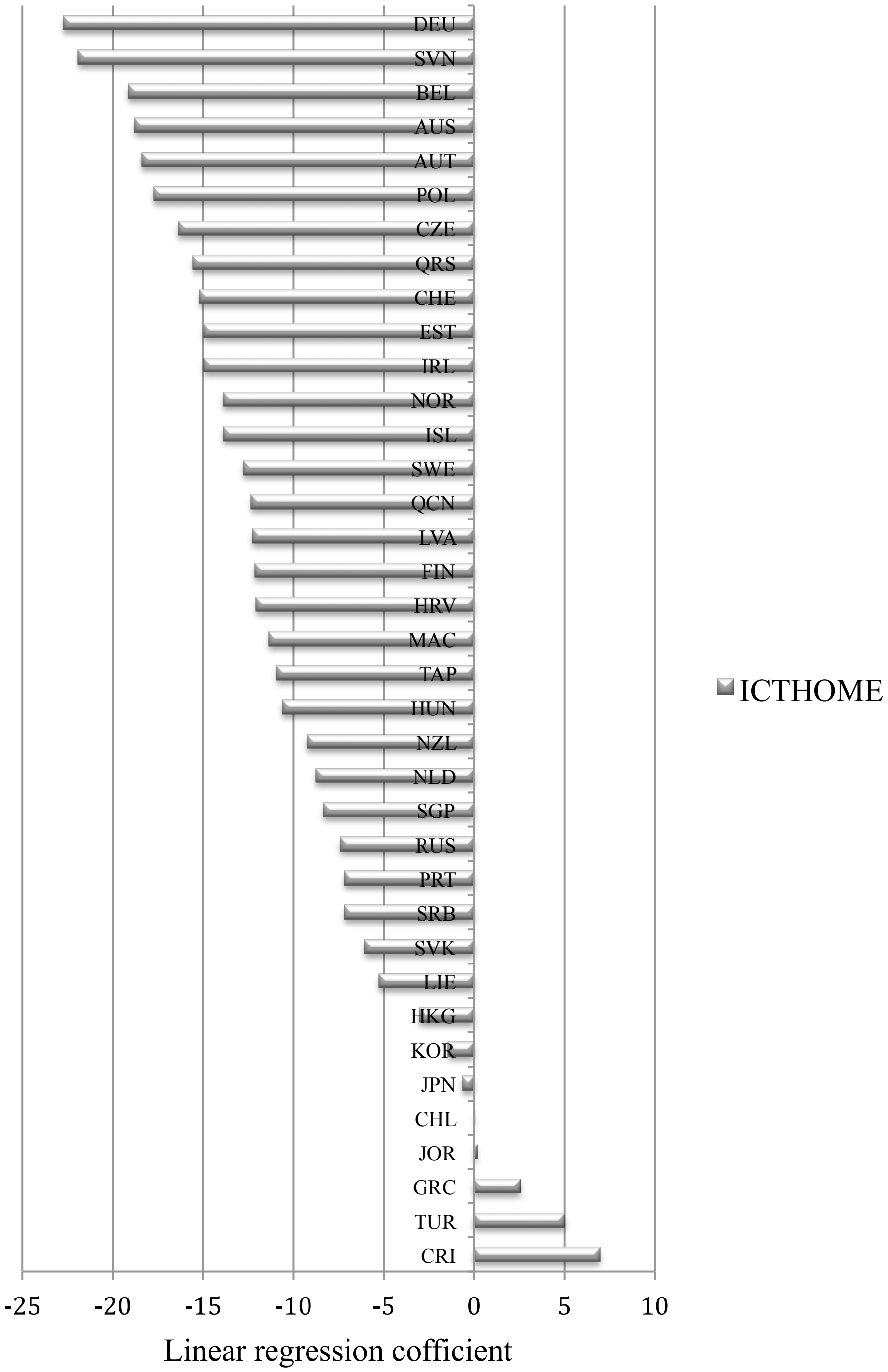


Figure 6.1. Bar chart of mathematics literacy as predicted by ICT availability at home (ICTHOME).

The overall results indicate that ICT availability at home (ICTHOME) is a negative and significant predictor of students’ mathematics literacyscores for the 37 selected countries and economies. More than 75% of the regression coefficients for ICTHOME were negatively significant. This model predicts that for every one unit increase or decrease in the standard deviation of ICTHOME, students’ mathematics literacy scores drop or increases by the corresponding regression coefficient index of that country, holding all other factors constant. However, for only two countries i.e. Costa Rica (6.97) and Turkey (5.02), the relationship was slightly positive and significant. Predicting that for a country such as Costal Rica, a change in one unit of standard deviation would influence an approximate seven points score on students’ mathematics literacy scale. For countries like Greece (2.57), Jordan (0.17) and Chile (0.05), the association was positive but insignificant, whereas, Japan (-0.65), Korea (-1.42), Hong Kong China (-3.04) and Liechtenstein (-5.28) registered a negative and insignificant relationship. For the rest of the countries, a significant and negative regression coefficient was observed, from Slovak Republic (-6.05) to Germany (-22.73).

6.4. Mathematics Literacy as Predicted by ICT Availability at School

Figure 6.2. presents the overall results of the multiple linear regression coefficients of ICTSCH in each of the 37 selected countries and economies, predicting mathematics literacy from PISA 2012 results. For a separate table ordering countries by decreasing regression coefficients of ICTSCH index, see Appendix B.2.

The overall result indicates that ICTSCH was a significant predictor of mathematics literacyscores for more than 50% of the 37 selected countries, though approximately 43% were negatively significant. Statistically, every one unit of increase or decrease in the standard deviation of ICTSCH, would result in an increase or decreases in students’ mathematics literacy scores by the corresponding regression index of that country, keeping all other predictor variable constant. However, the regression coefficients were merely positive and significant only for three countries, Turkey (5.90), Poland (3.71) and Slovak Republic (3.65). It was positive yet insignificant for countries like China Taipei, China Shanghai, Korea, Iceland, Latvia, Belgium, Perm Russian Federation, and Russian Federation. Meanwhile it is negative but not significant for Finland, Costal Rica, Slovenia, Hungary, Japan, Estonia, Chile, Norway, Sweden, and Portugal. The rest of the countries (43%) observed a significant but negative regression with variation in regression strength from Serbia (-3.21) to Liechtenstein (-18.66).

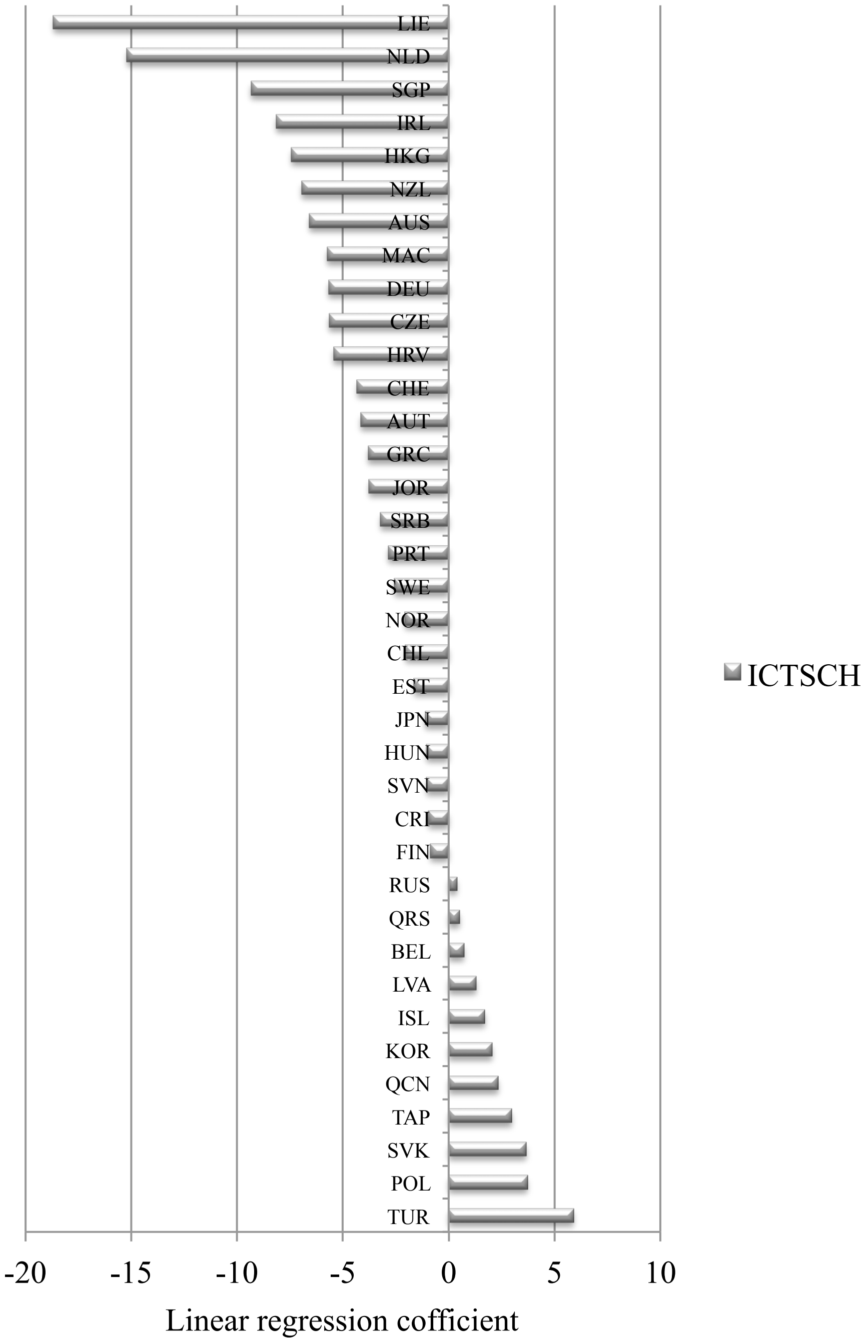


Figure 6.2. Bar chart of mathematics literacy as predicted by ICT availability at school (ICTSCH).

6.5. Mathematics Literacy as Predicted by ICT Use for Mathematics Lessons

Figure 6.3. demonstrates the overall results of the multiple linear regression coefficients of USEMATH in each of the 37 selected countries and economies, predicting mathematics literacy from PISA 2012 results. For a separate table ordering countries by decreasing regression coefficients of USEMATH index, see Appendix B.3.

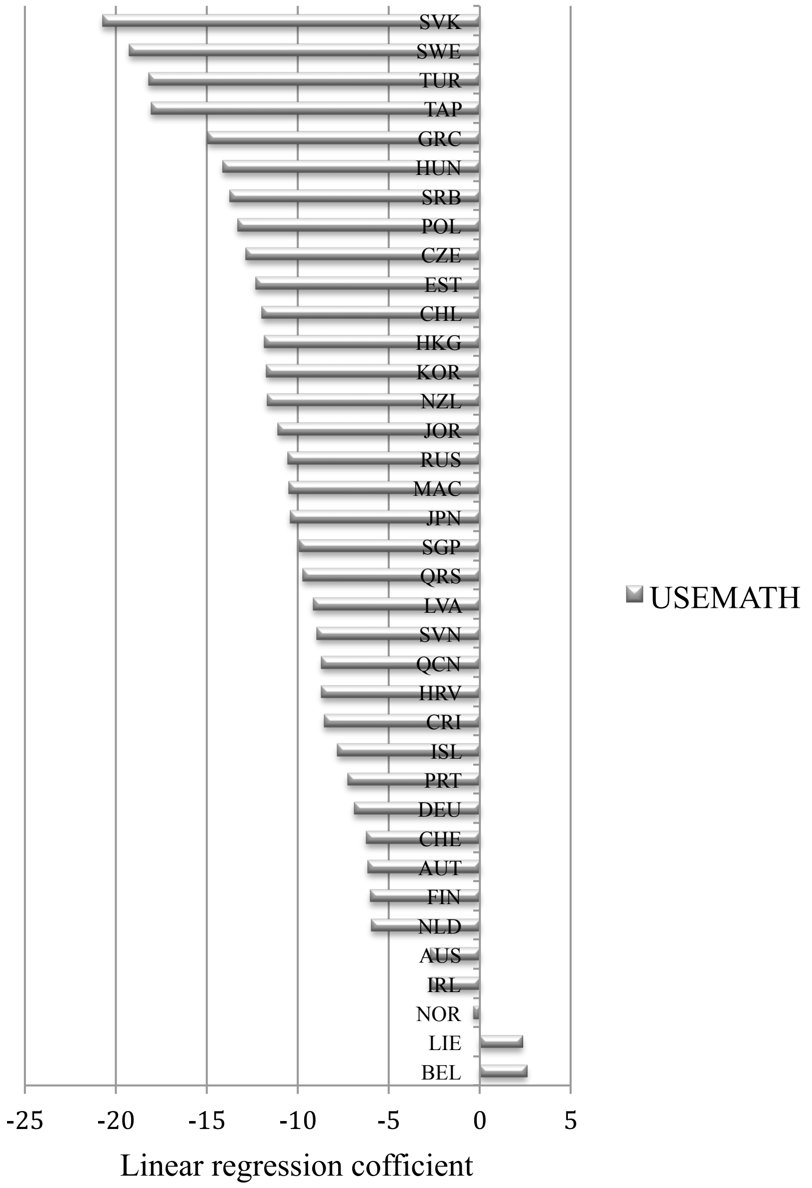


Figure 6.3. Bar chart of mathematics literacy as predicted by ICT used for mathematics lessons (USEMATH).

Surprisingly, an overview of the results indicates USEMATH as a negatively significant predictor of mathematics literacy scores forabout 90% of the 37 selected countries. According to the model, lower mathematics literacy scores would be obtained if students use additional ICT tools in learning mathematics for many countries in this study, given that other factors are controlled. However, for two countries, Belgium (2.56) and Liechtenstein (2.34), the association between USEMATH and students' mathematics literacy level was slightly positive and insignificant.It was negative and not significant in Norway (-0.33) and Ireland (-2.72) whereas the remaining countries, 89% showed a significant but negative relationship though with noticeable variation from Austria (-2.07) to Slovak Republic (-20.74).

6.6. Mathematics Literacy as Predicted by ICT Use at School

Figure 6.4. presents the overall results of the multiple linear regression coefficients of USESCH in each of the 37 selected countries and economies, predicting mathematics literacy from PISA 2012 results. For a separate table ordering countries by decreasing regression coefficients of USESCH index, see Appendix B.4.

Astonishingly, for more than 89% of the 37 selected countries, i.e. for 33 countries and economies, the results showed USESCH is a negatively significant predictor of 15-year-old students' mathematics literacyscores. The model suggest that, an increase in the number of ICTs for school use will produce a negative impact on the students' mathematics literacy level, when all other variables are controlled. However, for four countries [Iceland (-1.20), Ireland (-2.28), Austria (-2.90) and China Macao (-3.85)], the regression coefficient was negative but not significant. The regression coefficient strength was highest for Iceland (-1.20) and least for Liechtenstein (-25.91).

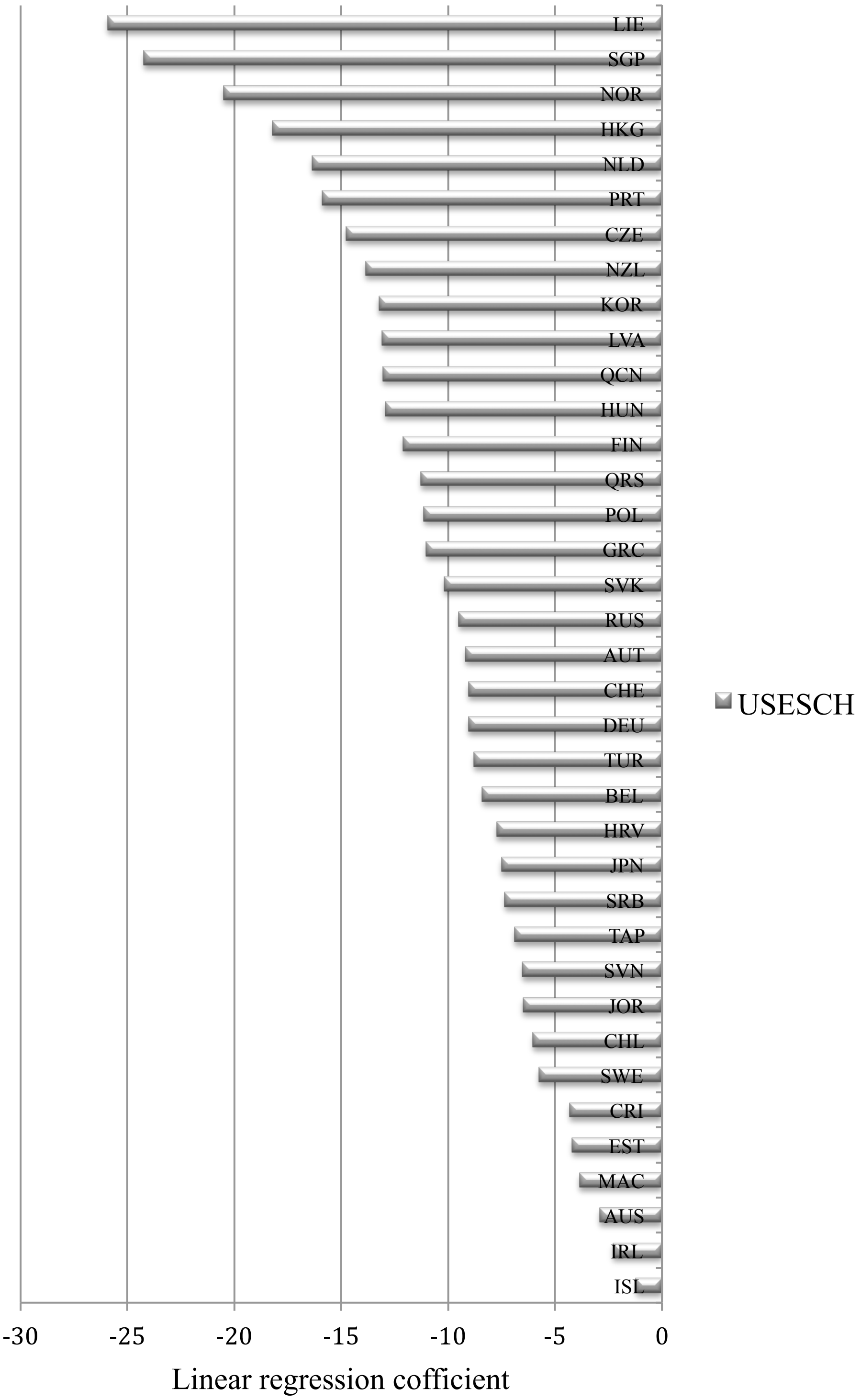


Figure 6.4. Bar chart of mathematics literacy as predicted by ICT used at school (USESCH).

6.7. Mathematics Literacy as Predicted by ICT Use at Home

Figure 6.5. shows the general results of the multiple linear regression coefficients of USEHOME in each of the 37 selected countries and economies, predicting mathematics literacy from PISA 2012 results. For a separate table ordering countries by decreasing regression coefficients of USEHOME index, see Appendix B.5.

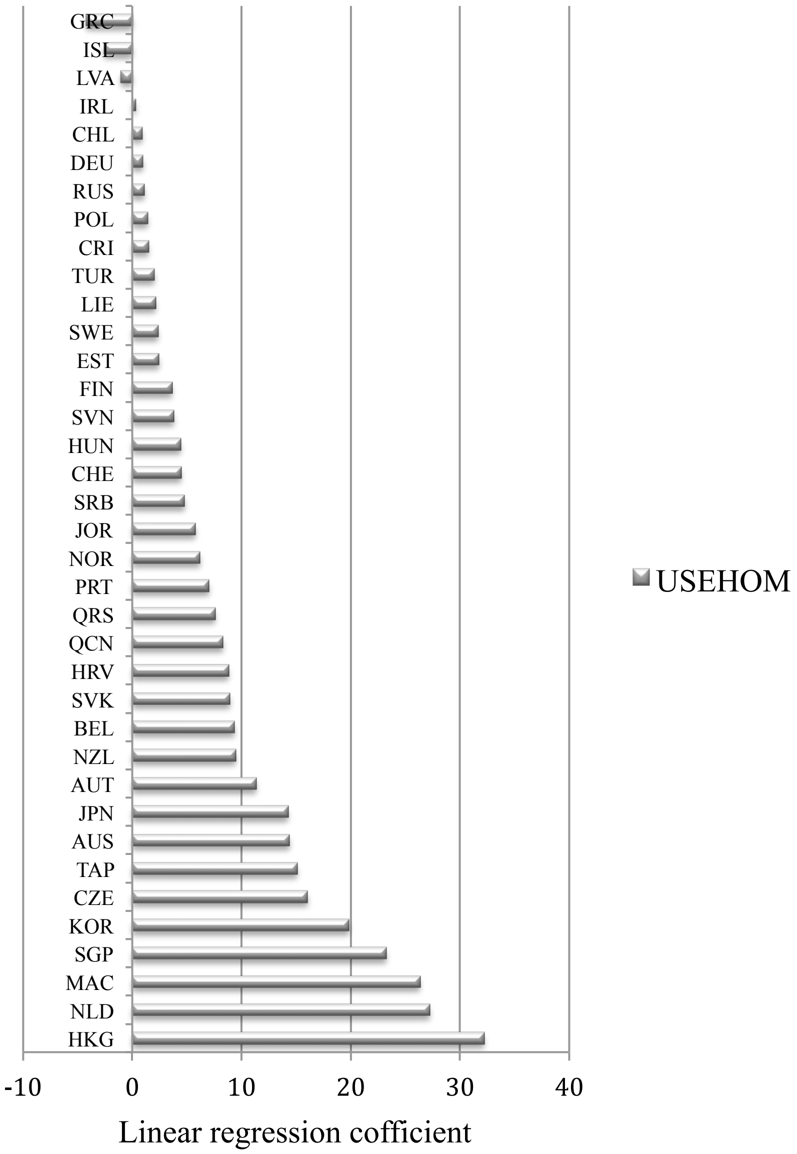


Figure 6.5. Bar chart of mathematics literacy as predicted by ICT used at home (USEHOME).

For 65% of the 37 selected countries and economies, the results show that USEHOME is a positive and significant predictor of students' mathematics literacyscores. The regression coefficients range from Hong Kong China (32.19) the highest, to Finland (3.64) as the least. In nine countries (Estonia, Sweden, Liechtenstein, Turkey, Costal Rica, Poland, Russian Federation, Germany, Chile and Ireland) a positive yet insignificant relationship was observed, but an insignificant and negative relationshipis observed for Latvia (-1.05) and Iceland (-2.57). Greece was the lone country that registered a barely negative significant association of ICT use at home and students' mathematics literacy scores.

6.8. Mathematics Literacy as Predicted by Student's ESCS

Figure 6.6. shows the general results of the multiple linear regression coefficients ofstudents' ESCS in each of the 37 selected countries and economies, predicting mathematics literacy from PISA 2012 results. For a separate table ordering countries by decreasing regression coefficients of ESCS index, see Appendix B.6.

According to these coefficients, student's ESCS is a positively significant predictor of the criterion variable for all 37 selected countries. Although, the coefficient strength varied from China Taipei (59.42) the highest, followed by New Zealand (52.46) down to China Macao (18.52) and Costal Rica (17.81) at the bottom. Based on the model, it can be concluded that for every extra unit increase in the standard deviation of ESCS, students' mathematics literacy scores is expected to boost by the corresponding regression coefficient index of that country, while maintaining other constructs constant.

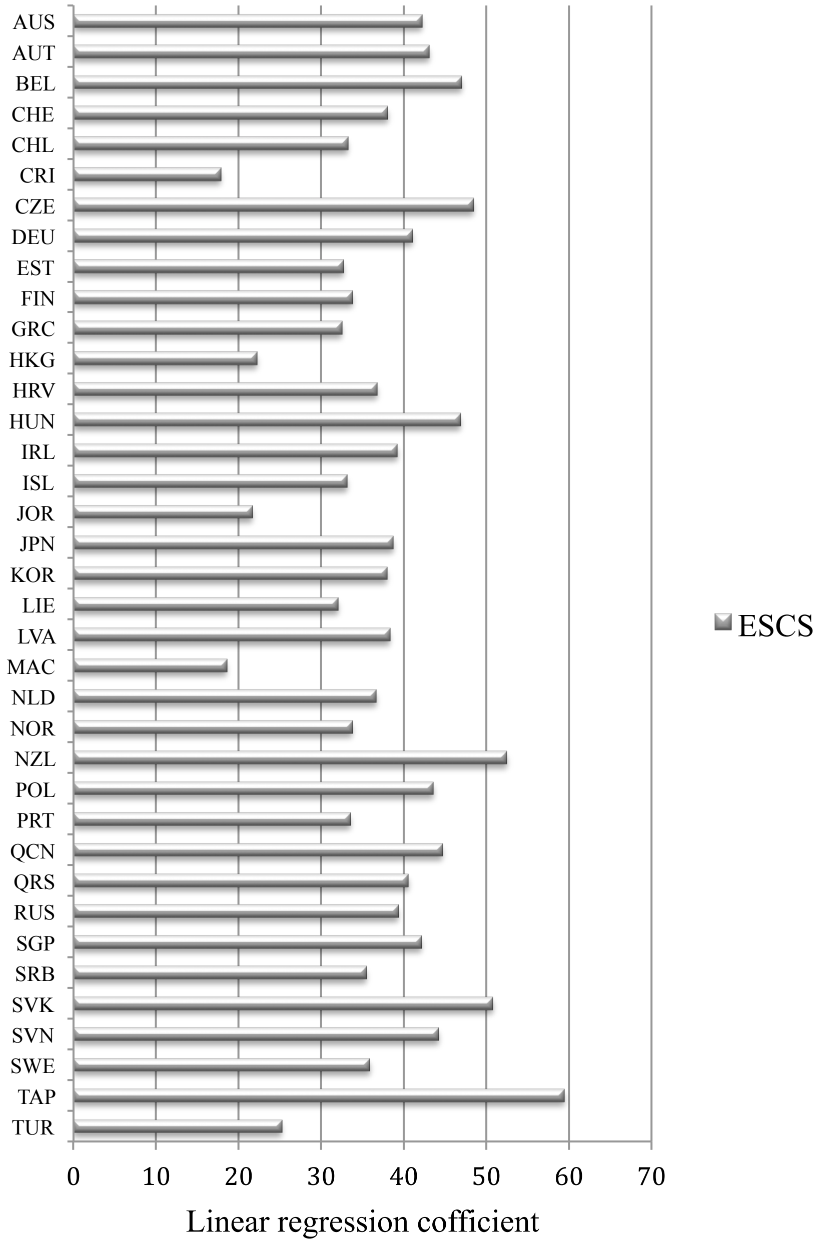


Figure 6.6. Bar chart of mathematics literacy as predicted by students' economic, social and cultural status (ESCS).

7. DISCUSSIONS AND CONCLUSION

7.1. Introduction

This last section will conclude by discussing the research findings and their practical implications for the teaching and learning of mathematics in secondary schools in the selected 37 countries and economies. Since the objective of this study was to determine the degree of association between availability and use of ICT, at home and at school and15-year-old students' mathematics literacy, using PISA 2012 data, suggestions for educational practice and recommendation for future research will be presented in this section. Thus the remaining of this section will be arranged in the following order: the relationship of each of the five predictor variables and mathematics literacy, the significance for educational practice, recommendations for schools authorities and education policy makers within the studied regions, limitations and suggestions for further study.

7.2. The Relationship Between Each Predictor Variable and Mathematics Literacy Scores from a MLR Analysis of Students' PISA 2012 Data

Surprisingly, therelationship established between ICT availability at home and students' mathematics literacy scores, from the analysiswas negative and significant for the majority of the selected countries and economies. It appears that for most of the countries, availability of ICT at home is not helping students to develop mathematical literacy. When ICT availability at home increased by one standard deviation, the mathematical literacy score drops by more than 10 points in 14 of the countries, a result consistentwith the finding of Papanastasiou (2005) and Şahinkayası (2008), who independently studied PISA data to establish a relationship between ICT availability at home on mathematical literacy. For eight countries the effect of ICT availability at home on mathematical literacy is insignificant. Only for Costa Rica and Turkey, the effect wasmerely significant and positive, thus a plus one increase in standard deviation of ICT availability at home effected only about five points on mathematics literacy score, which may be interpreted as a non critical contribution. Overall, these results corroborate previous research (e.g. Akçay, Durmaz, Tüysüz, and Feyzıoğlu, 2006, Leuven, 2004 and Becker, 2000), which found very little support of home computer availability to academic outcomes.

Based on this result, it is reasonable to guess that although students might have access to ICT at home, yet for the majority of the countries, students maystill not be using ICT in ways that promote mathematics literacy. Maybe, they access them more for entertainment and social networking. Therefore, if students are to improve their mathematics knowledge and skills through home ICT use, then parentsof all 37 countries who are the principal providers of home ICT to students must consider ways of controlling students access to ICT at home. For example, blocking access to undesirable components of the ICT, regulating the amount of time students spend on home ICT and providing assistanceat home as students study with ICT.

In 18 of the selected countries, the effect of availability of ICT at school on mathematics literacy was insignificant; in 16 countries the effect was significant and negative, and only in Turkey, Poland, and Slovak Republic that the effect was significant and positive. Although these countries may share some commonalities in geographical features, yet have contrast in the terms of GDP, language and culture (OCED, 2014) Astonishingly, for the majority of the countries ICT availability at school seems to hinder students' mathematical literacy. Similar results have earlier been observed by Leuven (2004), who reported that there was no clear evidence showing that availability of school ICT positively affects students' mathematics literacy. Furthermore, Fuchs and Woessmann (2004) argued that availability of ICT at school could promote mathematics literacy of students but once family background and school characteristics are controlled; the relationship turns from insignificant to negative.

The results of this study suggest that though schools of all 37 countries might be equipped with computers and Internet (ICT) facilities, the mere availability is not enough in producing significant and positive gains in mathematics literacy. Perhaps, making ICT available at school should be considered a necessary first step towards improving students' mathematical literacy, but effectively incorporating ICT in teaching/learningappears to be more challenging. A possible reason for which teachers and students may shy away from using the available school ICTs is the lack of basic knowledge and skills required to effectively operate some of those sophisticated technologies (Wenglinsky, 1998; NTCM, 2000 & Souter, 2001).

It is also interesting to note that Turkey is an outlier in terms of the effect of ICT availability both at home and school on mathematics literacy, for both variables Turkey registered significant and positive effects. Perhaps, Turkish educational system is on an evolutionally integration process to incorporate ICT in schools, thus both students and teacher are highly enthusiastic in improving mathematics literacy through school ICT. However, I strongly urge another study to investigation why ICT availability positively affects mathematics literacy in Turkey.

Based on this study, approximately 90 percent of the 37 countries registered a significantly negative association between USEMATH and student mathematics literacy scores. Not all countries are equivalent in the coefficient strength but the average model fits many countries and economies. This result aligns with the results of Vigdo and Ladd (2010), Wenglinsky (2006), Gil-Floras (2009), who independently reported that wrong selection of appropriate ICT or inappropriate use ICT by students and teachers serves as interrupter of learning school subjects like mathematics rather than as cognitive tool to facilitate learning.Moreover,it can be argued that young students provided with computing devices, mobile phones and Internet often start using them by searching and exploring the entertainment or communication components of the tool, rather than finding essential educational supportive applications of the device (Angrist & Lavy, 2002). It is reasonable to suggest from this study that efforts for ICT investment in education should focus on building students' and teachers' capability of ICT use rather than investing solely on classroom technology that has insignificant academic return when inappropriately used.

In Table 6.1, another interesting and surprising negative association between USESCH and mathematics literacy scoreswere observed for all 37 countries and economies. The negative effect of ICT use at school on mathematics literacy scores was significant except for four countries. The strength of the association is the largest for ICT use in school compared to the other predictors, for some countries like Iceland and Ireland, a plus one standard deviation raise in ICT use at school resulted in almost 20 points decrease in mathematics literacy. This result matches with the conclusion of Wenglinsky (1998) and

Angrist and Lavy (2002) who posited a negative effect of ICT use in schools on students' literacy scores in school subjects including mathematics. One way to explain this result is that a disparity may exists between teachers' perceptions of ICT in education and students' view in reality. Teachers usually focus on the potentials of technologies in improving students learning outcomes, neglecting the learning distraction components that come along with some of these devices. In effect, the manners in which student manipulate and interact with these technologies - for entertainment purpose, hardly match with the teachers' idealized view - for academic purpose (Becker, 2000).

This research indicates a positive relationship between USEHOME and mathematics literacy level for more than half of the 37 selected countries. This result seems to support the works of Attewell and Battle (1999), Papanastasiou and Ferdig (2010) and Stock and Fishman (2006), who found a positive effect of home computer use on students' literacy scores using the United States data from PISA. Stock and Fishman (2010) argue that home computer allows young students to practice what they have learnt in school at a convenient pace and time. Meaning they freely use home ICT without fear of their effort being monitored or criticized by peers or teacher. Using ICT under such tranquil atmosphere deepen understanding (Notten & Kraaykamp, 2009). On the contrary, scholars such as Becker (2000) argued that students are most likely to use home computers for entertainment purpose than school related purpose, which has a negative repercussion on their mathematics literacy in school.

According to this study, the association between students' ESCS and mathematics literacy scores was positive and significant for all of the 37 selected countries. Although not all countries are equivalent in terms of the coefficient strength, the average results seem to fit many countries. This confirms to some earlier studies, (Coleman et al., 1996; OCED, 2004a; Rumberger and Palardy, 2005; Sirin, 2005; Sui-Chu and Williams, 1996) which posited that students' ESCS could predict literacy scores across many school subjects. However, the students' ESCS indexes do not necessarily mean the country's Gross Domestics Product (GDP), because countries like China-Taipei that is topping the list does not reflect the country's wealth compared to the rest of the other 36 countries and economies. The same with Costa Rica at as not the poorest country even though found at the tail of the list.

7.3. Limitations and Recommendations for Future Studies

One major limitation of this study lies in the nature of the PISA data. This secondary data source was measured and collected in a single snapshot fashion. That is all the data analyzed in this study were measured and collected at one point in time, which means, there was no opportunity to measure students' prior abilities with ICTs. This explained why OECD, (2005) cautioned, "the usage of PISA data in associating computer access and usage with leaning performance, can not provide clear evidence of computers (ICTs) influence on learning, since the dataset do not demonstrate cause-effect relationship" (OCED, 2005, p 53). Therefore, any relationship between computer (ICT) accessibility and usage and 15-year-old students' mathematics literacy using PISA dataset can not be taken as full evidence of the influence of ICT use on students' mathematics literacy.

Definitely, many other factors such as students' interest/attitude, teachers' variables, classroom variables, etc. may affect students' mathematics literacy, but based on PISA 2012 dataset, this study is factors-wise restricted in fully examining ICT-related factors affecting 15-year-olds' mathematics literacy. Only ICT variables identified on PISA 2012 students' questionnaires were selected and still only those that were considered to be helpful in answering the research questions were retained.Therefore, as a recommendation to researchers interested in investigating the relationship between ICT accessibility and usage and students' mathematics literacy, an experimental study that would consider the effect of students' interest and learning with ICT would provide more meaningful understanding of this relationship.

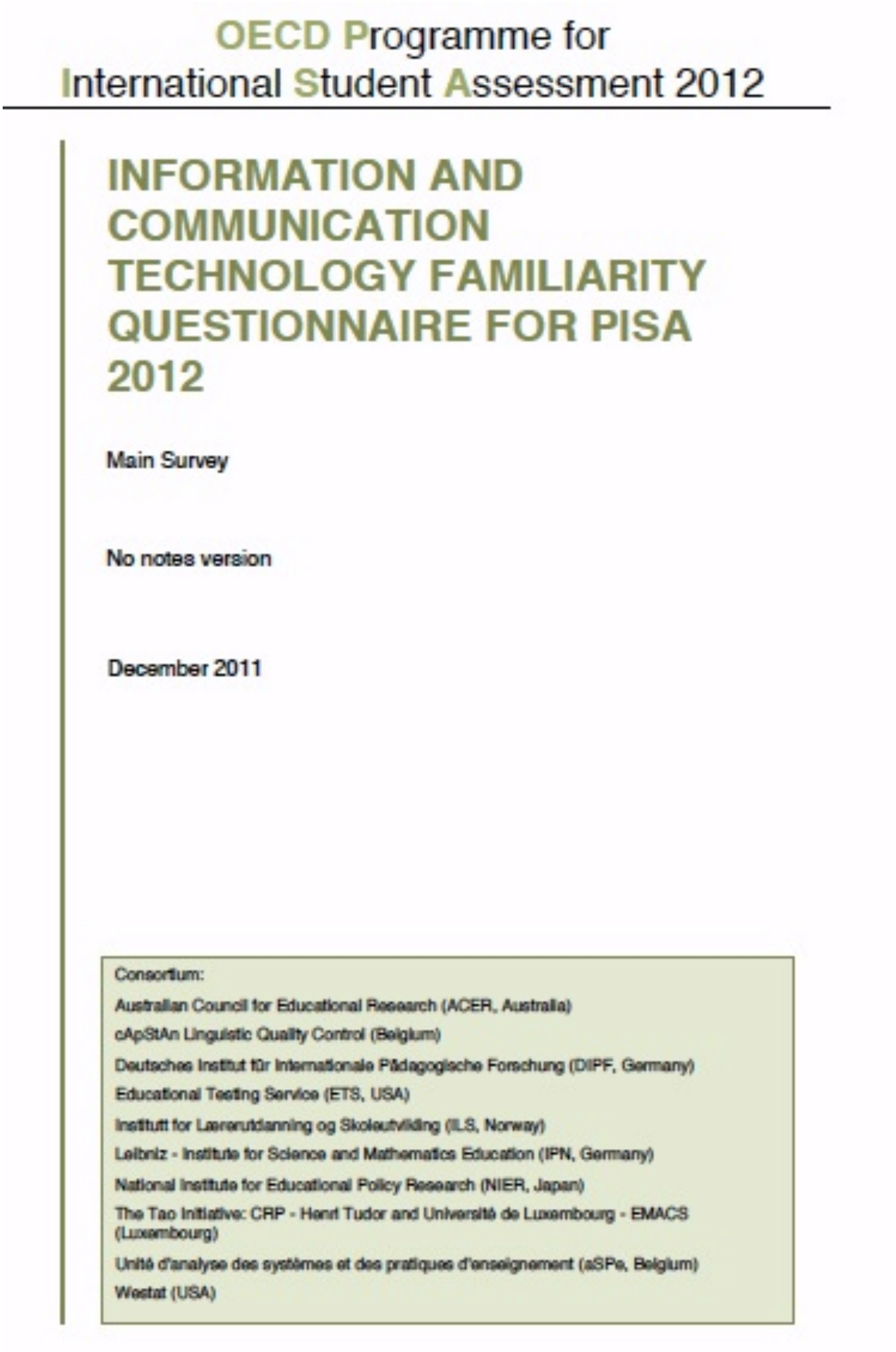
The two-stage stratification sampling technique employed by PISA only allow for random selection of students within schools, it is therefore not possible to investigate specific ICT related features at the classroom level. Thus looking for similarities and differences among the variables analyzed were restrain to school level and country level only. As a consequence, classroom ICT variables, such as different teaching and learning activities in class that could have contributed a better understanding of this relationship with mathematics literacy, cannot be determined from this dataset. Therefore, as a recommendation, a further study is need that will aggregate data from a wider perspective to allow for analysis at the classroom level, in addition to the country and school levels.

7.4. Implications and Suggestions for Policy-makers

Today, the computer and the Internet play an important role in almost very sector of the economy, not limited to education. Therefore, the need for ICT and general technological know-how is constantly on the raise among individuals' personal, civic and professional lives, and young students are not exception. ICT skill is fast becoming the major steering force for cognitive and economic growth. But in education, it would be an error to consider ICT as an educational remedy for all learning difficulties.

This study has shown that, the huge expenditures governments and school authorities spend in equipping schools and teachers with ICT resources could yield better returns if these resources were invested in reinforcing the traditional foundation of education (for example, employing more qualified teachers, filling library shelves with more books and creating a more learning environment in the classroom). Based on the result of this study, should governments and policy-makers decide to improve students' mathematics literacy in schools through ICT use, thenthe efforts and strategies appear to be better directed towards facilitating students' home ICT access and use rather than school ICT. Evidence from this studysupport home ICT use rather than school ICT use for improving students' mathematics literacy for most of the 37 countries except of Greece, Latvia and Iceland. One suggestion for these governments is to reduce public expenditures on school ICT and increase government subvention and subsidy for home ICT. Another way to improving mathematics literacy mean scores on PISA test at country level is to equitably distribute social capital to school students in all 37 countries and economies, since students' ESCS is a good predictor of mathematics literacy scores.

APPENDIX A: ICT FAMILIARITY QUESTIONNAIRE FOR PISA 2012



OECD Programme for
International Student Assessment 2012

INFORMATION AND COMMUNICATION TECHNOLOGY FAMILIARITY QUESTIONNAIRE FOR PISA 2012

Main Survey

No notes version

December 2011

Consortium:
Australian Council for Educational Research (ACER, Australia)
cApStAn Linguistic Quality Control (Belgium)
Deutsches Institut für Internationale Pädagogische Forschung (DIPF, Germany)
Educational Testing Service (ETS, USA)
Institutt for Lærerutdanning og Skoleutvikling (ILS, Norway)
Leibniz - Institute for Science and Mathematics Education (IPN, Germany)
National Institute for Educational Policy Research (NIER, Japan)
The Tao Initiative: CRP - Henri Tudor and Université de Luxembourg - EMACS (Luxembourg)
Unité d'analyse des systèmes et des pratiques d'enseignement (aSPe, Belgium)
Westat (USA)

SECTION <X>: AVAILABILITY OF ICT

IC01

Q Are any of these devices available for you to use at home?

(Please tick one box in each row.)

	Yes, and I use it	*Yes, but I don't use it*	*No*
a) Desktop computer	☐ 1	☐ 2	☐ 3
b) Portable laptop, or notebook	☐ 1	☐ 2	☐ 3
c) <Tablet computer> (e.g. <iPad®>, <BlackBerry® PlayBook™>)	☐ 1	☐ 2	☐ 3
d) Internet connection	☐ 1	☐ 2	☐ 3
e) <Video games console>, e.g. <Sony® PlayStation® >	☐ 1	☐ 2	☐ 3
f) <Cell phone> (without Internet access)	☐ 1	☐ 2	☐ 3
g) <Cell phone> (with Internet access)	☐ 1	☐ 2	☐ 3
h) Portable music player (Mp3/Mp4 player, iPod® or similar)	☐ 1	☐ 2	☐ 3
i) Printer	☐ 1	☐ 2	☐ 3
j) USB (memory) stick	☐ 1	☐ 2	☐ 3
k) <ebook reader>, e.g. <Amazon® Kindle™>	☐ 1	☐ 2	☐ 3

IC02

Q Are any of these devices available for you to use <u>at school</u>?

(Please tick one box in each row.)

	Yes, and I use it	*Yes, but I don't use it*	*No*
a) Desktop computer	☐1	☐2	☐3
b) Portable laptop or notebook	☐1	☐2	☐3
c) <Tablet computer> (e.g. <iPad®>, <BlackBerry® PlayBook™>)	☐1	☐2	☐3
d) Internet connection	☐1	☐2	☐3
e) Printer	☐1	☐2	☐3
f) USB (memory) stick	☐1	☐2	☐3
g) <ebook reader>, e.g. <Amazon® Kindle™>	☐1	☐2	☐3

SECTION <X>: GENERAL COMPUTER USE

IC03

Q How old were you when you first used a computer?

(Please tick only one box.)

6 years old or younger	*7-9 years old*	*10-12 years old*	*13 years old or older*	*I have never used a computer*
☐1	☐2	☐3	☐4	☐5

If you have <u>never</u> used a computer, please stop here. Thank you for your participation.
<Instructions>

IC04

Q **How old were you when you first accessed the Internet?**

(Please tick only one box.)

6 years old or younger	*7-9 years old*	*10-12 years old*	*13 years old or older*	*I have never accessed the Internet*
☐1	☐2	☐3	☐4	☐5

IC05

Q **During a *typical* weekday, for how long do you use the Internet at school?**

(Please tick only one box.)

No time	*1-30 minutes per day*	*31-60 minutes per day*	*Between 1 hour and 2 hours per day*	*Between 2 hours and 4 hours per day*	*Between 4 hours and 6 hours per day*	*More than 6 hours per day*
☐01	☐02	☐03	☐04	☐05	☐06	☐07

IC06

Q **During a *typical* weekday, for how long do you use the Internet outside of school?**

(Please tick only one box.)

No time	*1-30 minutes per day*	*31-60 minutes per day*	*Between 1 hour and 2 hours per day*	*Between 2 hours and 4 hours per day*	*Between 4 hours and 6 hours per day*	*More than 6 hours per day*
☐01	☐02	☐03	☐04	☐05	☐06	☐07

IC07

Q **On a *typical* weekend day, for how long do you use the Internet outside of school?**

(Please tick only one box.)

No time	*1-30 minutes per day*	*31-60 minutes per day*	*Between 1 hr and 2 hours per day*	*Between 2 hrs and 4 hours per day*	*Between 4 hrs and 6 hours per day*	*More than 6 hours per day*
☐01	☐02	☐03	☐04	☐05	☐06	☐07

SECTION <X>: USE OF ICT OUTSIDE OF SCHOOL

IC08

Q How often do you use a computer for the following activities outside of school?

(Please tick one box in each row.)

	Never or hardly ever	*Once or twice a month*	*Once or twice a week*	*Almost every day*	*Every day*
a) Playing one-player games.	☐1	☐2	☐3	☐4	☐5
b) Playing collaborative online games.	☐1	☐2	☐3	☐4	☐5
c) Using email.	☐1	☐2	☐3	☐4	☐5
d) <Chatting online> (e.g. <MSN®>).	☐1	☐2	☐3	☐4	☐5
e) Participating in social networks (e.g. <facebook>, <MySpace>).	☐1	☐2	☐3	☐4	☐5
f) Browsing the Internet for fun (such as watching videos, e.g<YouTube™>).	☐1	☐2	☐3	☐4	☐5
g) Reading news on the Internet (e.g. current affairs).	☐1	☐2	☐3	☐4	☐5
h) Obtaining practical information from the Internet (e.g. locations, dates of events).	☐1	☐2	☐3	☐4	☐5
i) Downloading music, films, games or software from the Internet.	☐1	☐2	☐3	☐4	☐5
j) Uploading your own created contents for sharing (e.g. music, poetry, videos, computer programs).	☐1	☐2	☐3	☐4	☐5

IC09

Q How often do you use a computer for the following activities outside of school?

(Please tick one box in each row.)

	Never or hardly ever	*Once or twice a month*	*Once or twice a week*	*Almost every day*	*Every day*
a) Browsing the Internet for schoolwork (e.g. for preparing an essay or presentation).	☐1	☐2	☐3	☐4	☐5
b) Using email for communication with other students about schoolwork.	☐1	☐2	☐3	☐4	☐5
c) Using email for communication with teachers and submission of homework or other schoolwork.	☐1	☐2	☐3	☐4	☐5
d) Downloading, upload or browse material from my school's website (e.g. time table or course materials).	☐1	☐2	☐3	☐4	☐5
e) Checking the school's website for announcements, e.g. absence of teachers.	☐1	☐2	☐3	☐4	☐5
f) Doing homework on the computer.	☐1	☐2	☐3	☐4	☐5
g) Sharing school related materials with other students.	☐1	☐2	☐3	☐4	☐5

SECTION <X>: USE OF ICT AT SCHOOL

IC10

Q How often do you use a computer for the following activities at school?

(Please tick one box in each row.)

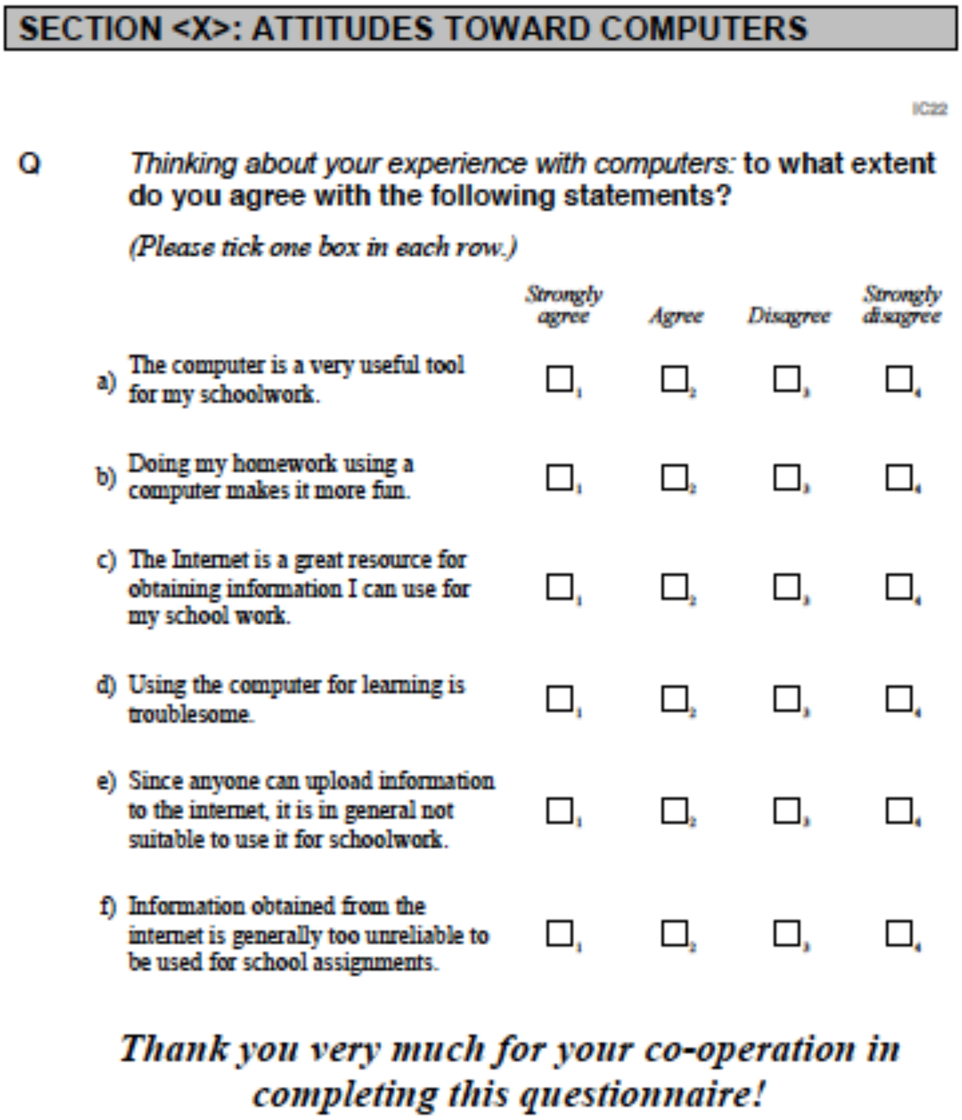
	Never or hardly ever	*Once or twice a month*	*Once or twice a week*	*Almost every day*	*Every day*
a) <Chatting on line> at school.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
b) Using email at school.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
c) Browsing the Internet for schoolwork.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
d) Downloading, uploading or browsing material from the school's website (e.g. <intranet>).	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
e) Posting my work on the school's website.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
f) Playing simulations at school.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
g) Practicing and drilling, such as for foreign language learning or mathematics.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
h) Doing homework on a school computer.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$
i) Using school computers for group work and communication with other students.	☐$_1$	☐$_2$	☐$_3$	☐$_4$	☐$_5$

IC11

Q **Within the last month, has a computer ever been used for the following purposes in your <u>mathematics lessons</u>?**

(Please tick one box in each row.)

	Yes, students did this	*Yes, but only the teacher demonstrated this*	*No*
a) Drawing the graph of a function (such as $y = 4x+6$).	☐1	☐2	☐3
b) Calculating with numbers (such as calculating 5*233/8).	☐1	☐2	☐3
c) Constructing geometric figures (e.g. an equilateral triangle with given side lengths).	☐1	☐2	☐3
d) Entering data in a spreadsheet (e.g. in <Excel™>).	☐1	☐2	☐3
e) Rewriting algebraic expressions and solving equations (such as $a^2+2ab+b^2$).	☐1	☐2	☐3
f) Drawing histograms (a graph that shows the distribution of frequencies of data).	☐1	☐2	☐3
g) Finding out how the graph of a function like $y=ax^2$ changes depending on a.	☐1	☐2	☐3



SECTION <X>: ATTITUDES TOWARD COMPUTERS

IC22

Q *Thinking about your experience with computers:* **to what extent do you agree with the following statements?**

(Please tick one box in each row.)

	Strongly agree	*Agree*	*Disagree*	*Strongly disagree*
a) The computer is a very useful tool for my schoolwork.	☐$_1$	☐$_2$	☐$_3$	☐$_4$
b) Doing my homework using a computer makes it more fun.	☐$_1$	☐$_2$	☐$_3$	☐$_4$
c) The Internet is a great resource for obtaining information I can use for my school work.	☐$_1$	☐$_2$	☐$_3$	☐$_4$
d) Using the computer for learning is troublesome.	☐$_1$	☐$_2$	☐$_3$	☐$_4$
e) Since anyone can upload information to the internet, it is in general not suitable to use it for schoolwork.	☐$_1$	☐$_2$	☐$_3$	☐$_4$
f) Information obtained from the internet is generally too unreliable to be used for school assignments.	☐$_1$	☐$_2$	☐$_3$	☐$_4$

Thank you very much for your co-operation in completing this questionnaire!

APPENDIX B: TABLES OF REGRESSION INDICE

B.1. The Relationship between ICT Availability at Home and Mathematics Literacy from a MLR Analysis of PPISA 2012 Data

	Intercept	**ICTHOME**	ICTSCH	USEMATH	USESCH	USEHOME	ESCS
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
LIE	541.931*	-5.28	-18.657*	2.344	-25.906*	2.137	32.004*
SVK	493.052*	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
TAP	578.861*	-10.91*	2.966	-18.07*	-6.874*	15.08*	59.423*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.8748
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
NOR	498.0658*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.20468
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
AUT	513.586*	-18.416*	-4.139	-6.163*	-9.174*	11.331*	43.027*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
SVN	498.8668	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*

B.2.The Relationship between ICT Availability at School and Mathematics Literacy from a MLR Analysis of PPISA 2012 Data

	Intercept	ICTHOME	**ICTSCH**	USEMATH	USESCH	USEHOME	ESCS
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
SVK	493.052*	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*
TAP	578.861*	-10.91*	2.966	-18.07*	-6.874*	15.08*	59.423*
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*
SVN	498.866*	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
NOR	498.0658*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.874*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*
AUT	513.586*	-18.416*	-4.139*	-6.163*	-9.174*	11.331*	43.027*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.2046*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
LIE	541.931*	-5.28	-18.657*	2.344	-25.906*	2.137	32.004*

Note: *= statistically significant at α = 0.05 level.

B.3. The Relationship between ICT Use for Mathematics Lessons & Mathematics Literacy from a MLR Analysis of PPISA 2012 Data

	Intercept	ICTHOME	ICTSCH	**USEMATH**	USESCH	USEHOME	ESCS
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
LIE	541.931*	-5.28	-18.657	2.344	-25.906*	2.137	32.004*
NOR	498.0658*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.2046*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
AUT	513.586*	-18.416*	-4.139	-6.163*	-9.174*	11.331*	43.027*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
SVN	498.866*	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*
TAP	578.861*	-10.91*	2.966	-18.07*	-6.874*	15.08*	59.423*
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.874*
SVK	493.052*	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*

Note: *= statistically significant at α = 0.05 level.

B.4.The Relationship between ICT Use at School and Mathematics Literacy from a MLR Analysis of PPISA 2012 Data

	Intercept	ICTHOME	ICTSCH	USEMATH	USESCH	USEHOME	ESCS
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.2046*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.874*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*
SVN	498.866*	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
TAP	578.861*	-10.91*	2.966	-18.07*	-6.874*	15.08*	59.423*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
AUT	513.586*	-18.416*	-4.139	-6.163*	-9.174*	11.331*	43.027*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
SVK	493.052*	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
NOR	498.0658*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
LIE	541.931*	-5.28	-18.657	2.344	-25.906*	2.137	32.004*

Note: *= statistically significant at α = 0.05 level.

B.5.The Relationship between ICT Use at Home and Mathematics Literacy from a MLR Analysis of PPISA 2012 Data

	Intercept	ICTHOME	ICTSCH	USEMATH	USESCH	**USEHOME**	ESCS
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
TAP	578.861*	-10.91*	2.966	-18.07*	-6.874*	15.08*	59.423*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
AUT	513.586*	-18.416*	-4.139	-6.163*	-9.174*	11.331*	43.027*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
SVK	493.052*	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
NOR	498.065*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
SVN	498.866*	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.874*
LIE	541.931*	-5.28*	-18.657	2.344	-25.906*	2.137	32.004*
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.2046*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*

Note: *= statistically significant at α = 0.05 level.

B.6. The Relationship between Students' ESCS and Mathematics Literacy from aMLR Analysis of PPISA 2012 Data

	Intercept	ICTHOME	ICTSCH	USEMATH	USESCH	USEHOME	**ESCS**
TAP	578.861*	-10.91*	2.966	-18.07*	-6.874*	15.08*	59.423*
NZL	510.762*	-9.25*	-6.925*	-11.699*	-13.843*	9.447*	52.457*
SVK	493.052*	-6.047*	3.651*	-20.737*	-10.175*	8.924*	50.765*
CZE	501.746*	-16.383*	-5.642*	-12.846*	-14.761*	16.02*	48.402*
BEL	527.4331*	-19.1453*	0.7092	2.5622	-8.3883*	9.3146*	46.9777*
HUN	487.548*	-10.611*	-1.042	-14.129*	-12.94*	4.417*	46.848*
QCN	616.481*	-12.348*	2.33	-8.702*	-13.043*	8.282*	44.662*
SVN	498.866*	-21.892*	-1.04	-8.953*	-6.51*	3.8*	44.189*
POL	521.138*	-17.731*	3.713*	-13.317*	-11.111*	1.403	43.544*
AUT	513.586*	-18.416*	-4.139	-6.163*	-9.174*	11.331*	43.027*
AUS	507.617*	-18.77*	-6.575*	-2.722*	-2.902	14.389*	42.184*
SGP	584.027*	-8.339*	-9.331*	-9.933*	-24.213*	23.245*	42.111*
DEU	520.6181*	-22.7313*	-5.6738*	-6.8957*	-9.0264*	0.9576	41.0363*
QRS	486.4625*	-15.5643*	0.5052	-9.7246*	-11.2611*	7.5752*	40.5223*
RUS	488.3315*	-7.4296*	0.3889	-10.5651*	-9.4865*	1.1068	39.3035*
IRL	500.8435*	-14.9526*	-8.1295*	-2.7203	-2.2794	0.3269	39.2046*
JPN	549.613*	-0.6509	-1.0998	-10.4058*	-7.4962*	14.2417*	38.713*
LVA	495.547*	-12.268*	1.29	-9.165*	-13.085*	-1.049	38.295*
CHE	532.066*	-15.184*	-4.322*	-6.24*	-9.03*	4.471*	38.022*
KOR	546.411*	-1.416	2.043	-11.713*	-13.229*	19.813*	37.954*
HRV	479.216*	-12.073*	-5.429*	-8.679*	-7.723*	8.792*	36.736*
NLD	527.453*	-8.746*	-15.184*	-5.937*	-16.352*	27.211*	36.632*
SWE	477.292*	-12.77*	-2.554	-19.257*	-5.745*	2.345	35.874*
SRB	459.354*	-7.165*	-3.208*	-13.721*	-7.331*	4.787*	35.455*
FIN	513.2808*	-12.1467*	-0.8578	-6.0249*	-12.109*	3.635*	33.7729*
NOR	498.0658*	-13.8841*	-2.0574	-0.3314	-20.4941*	6.1715*	33.7105*
PRT	506.24*	-7.179*	-2.842	-7.263*	-15.867*	7.012*	33.519*
CHL	442.96941*	0.04919	-2.03577	-11.95564*	-6.02543*	0.89527	33.1732*
ISL	472.923*	-13.88*	1.705	-7.804*	-1.197	-2.566	33.096*
EST	514.844*	-14.959*	-1.623	-12.324*	-4.184*	2.436	32.688*
GRC	461.44*	2.569	-3.794*	-14.952*	-11.02*	-4.222*	32.471*
LIE	541.931*	-5.28	-18.657*	2.344	-25.906*	2.137	32.004*
TUR	495.918*	5.024*	5.898*	-18.22*	-8.778*	1.995	25.175*
HKG	578.414*	-3.039	-7.419*	-11.82*	-18.195*	32.185*	22.224*
JOR	413.8847*	0.1699	-3.7519*	-11.0842*	-6.4945*	5.7546*	21.6409*
MAC	556.33*	-11.359*	-5.725*	-10.476*	-3.853	26.31*	18.515*
CRI	431.0304*	6.965*	-0.9436	-8.5679*	-4.3046*	1.4712	17.8101*

Note: *= statistically significant at α = 0.05 level.

REFERENCES

Archer, K., R. Savage, S. Sanghera-Sidhu, E. Wood, A. Gottardo, and V. Chen, 2014, "Examining the Effectiveness of Technology Use in Classrooms: A Tertiary Meta-Analysis", *Computers & Education,* Vol. 78, No. 0, pp. 140-149.

Attewell, P. and J. Battle, 1999, "Home Computers and School Performance", *Information Society,* Vol. 15, No. 1, pp. 1-10.

Bay, H., 2014, "Student Performance In PISA 2012 (Mathematics) Explained by Gender, Immigrant Background, Index of Economic, Social and Cultural Status for Students and Schools", *Varazdin Development and Entrepreneurship Agency (VADEA),* pp. 313.

Biagi, F. and M. Loi, 2013, "Measuring ICT Use and Learning Outcomes: Evidence from Recent Econometric Studies", *European Journal of Education,* Vol. 48, No. 1, pp. 28-42.

Bielefeldt, T., 2005, "Computers and Student Learning: Interpreting the Multivariate Analysis of PISA 2000", *Journal of Research on Technology in Education,* Vol. 37, No. 4, pp. 339-347.

Casey, A., R. Layte, S. Lyons and M. Silles, 2012, "Home Computer Use and Academic Performance of Nine-Year-Olds", *Oxford Review of Education,* Vol. 38, No. 5, pp. 617-634.

Cheema, J.R. and B. Zhang, 2013, "Quantity and Quality of Computer Use and Academic Achievement: Evidence from a Large-scale International Test Program", *International Journal of Education and Development using Information and Communication Technology,* Vol. 9, No. 2, pp. 95-106.

De Witte, K. and N. Rogge, 2014, "Does ICT Matter for Effectiveness and Efficiency in Mathematics Education", *Computers & Education,* Vol. 75, No. 0, pp. 173-184.

Delen, E. and O. Bulut, 2011, "The Relationship between Students' Exposure to Technology and Their Achievement in Science and Math", *Turkish Online Journal of Educational Technology - TOJET,* Vol. 10, No. 3, pp. 311-317.

Draper, S., 2013, *The influence of fourth grade students' use of technology on mathematics academic achievement*, St. John's University (New York), School of Education and Human Services.

Duncan, D.K., A.R. Hoekstra and B.R. Wilcox, 2002, "Digital Devices, Distraction, and Student Performance: Does In-Class Cell Phone Use Reduce Learning", *Astronomy Education Review,* Vol. 11, No. 1, pp. 010108-1-010108-4.

Eng, T.S., 2005, "The Impact of ICT on Learning: A Review of Research", *International Education Journal,* Vol. 6, No. 5, pp. 635-650.

Erdogdu, F. and E. Erdogdu, 2015, "The Impact of Access to ICT, Student Background and School/Home Environment on Academic Success of Students in Turkey: An International Comparative Analysis", *Computers & Education,* Vol. 82, No. 0, pp. 26-49.

Fariña, P., E. San-Martín, D.D. Preiss, M. Claro and I. Jara, 2015, "Measuring the Relation between Computer Use and Reading Literacy in the Presence of Endogeneity", *Computers & Education,* Vol. 80, No. 0, pp. 176-186.

Fischbach, A., U. Keller, F. Preckel, and M. Brunner, 2013, "PISA Proficiency Scores Predict Educational Outcomes", *Learning and Individual Differences,* Vol. 24, No. 0, pp. 63-72

Gumus, S., 2013, "Investigating the Factors Affecting Information and Communication Technology (ICT) Usage of Turkish Students in PISA 2009", *Turkish Online Journal of Educational Technology - TOJET,* Vol. 12, No. 1, pp. 102-107.

Guzeller, C.O. and A. Akin, 2014, "Relationship between ICT Variables and Mathematics Achievement Based on PISA 2006 Database: International Evidence", *Turkish Online Journal of Educational Technology - TOJET,* Vol. 13, No. 1, pp. 184-192.

Isman, A. and G.E. Celikli, 2009, "How Does Student Ability and Self-Efficacy Affect the Usage of Computer Technology", *Online Submission*.

Jonassen, D.H., C. Carr, and H. Yueh, 1998, "Computers as Mind tools for Engaging Learners in Critical Thinking", *TechTrends,* Vol. 43, No. 2, pp. 24-32.

Judge, S., 2005, "The Impact of Computer Technology on Academic Achievement of Young African American Children", *Journal of Research in Childhood Education,* Vol. 20, No. 2, p. 91.

Kebritchi, M., 2008, *Effects of a Computer Game on Mathematics Achievement and Class Motivation: An Experimental Study*, University of Central Florida.

Keengwe, J., G. Onchwari, and P. Wachira, 2008, "The Use of Computer Tools to Support Meaningful Learning", *AACE Journal,* Vol. 16, No. 1, pp. 77-92.

Kim, S. and M. Chang, 2010, "Does Computer Use Promote the Mathematical Proficiency of ELL Students", *Journal of Educational Computing Research,* Vol. 42, No. 3, pp. 285-305.

Kirschner, P.A. and G. Erkens, 2006, "Cognitive Tools and Mind tools for Collaborative Learning", *Journal of Educational Computing Research,* Vol. 35, No. 2, pp. 199-209.

Lei, J., 2010, "Quantity versus Quality: A New Approach to Examine the Relationship between Technology Use and Student Outcomes", *British Journal of Educational Technology,* Vol. 41, No. 3, pp. 455-472.

Livingstone, S., 2012, "Critical Reflections on the Benefits of ICT in Education", *Oxford Review of Education,* Vol. 38, No. 1, pp. 9-24.

Luu, K. and J.G. Freeman, 2011, "An Analysis of the Relationship between Information and Communication Technology (ICT) and Scientific Literacy in Canada and Australia", *Computers & Education,* Vol. 56, No. 4, pp. 1072-1082.

Mcconney, A. and L.B. Perry, 2010, "Socioeconomic Status, Self-efficacy, and Mathematics Achievement in Australia: A Secondary Analysis", *Educational Research for Policy and Practice,* Vol. 9, No. 2, pp. 77-91.

McNew, S.J., 2008, *The Relationship of Handheld Computer Use to Student Achievement in Middle School Mathematics*, The University of Toledo.

Nettelbeck, D., 2012, "Computers and Learning: Does ICT Really Change the Way Secondary Students Learn" *English in Australia,* No. 134, pp. 78-85.

O'Dwyer, L.M., M. Russell, D. Bebell, and K. Seeley, 2008, "Examining the Relationship between Students' Mathematics Test Scores and Computer Use at Home and at School", *Journal of Technology, Learning, and Assessment,* Vol. 6, No. 5.

OECD, 2014, *PISA 2012 Results: What Students Know and Can Do (Volume I, Revised edition, February 2014),*

OECD, 2013, "Background Questionnaires" in, pp. 209-258.

OECD, 2013, "Context Questionnaires Framework" *OECD*, pp. 167-207.

OECD, 2013, *PISA 2012 Assessment and Analytical Framework,* OECD.

OECD, 2013, "What is PISA", *OECD*, pp. 23-27.

OECD, 2009, *PISA Data Analysis Manual: SAS, Second Edition,* OECD.

Petty, T., C. Wang, and A.P. Harbaugh, 2013, "Relationships between Student, Teacher, and School Characteristics and Mathematics Achievement", *School Science and Mathematics,* Vol. 113, No. 7, pp. 333-344.

Pope, S., 2013, "Technology in Mathematics Education", *Mathematics Teaching,* No. 234, pp. 6-83.

Raines, J.M. and L.M. Clark, 2011, "A Brief Overview on Using Technology to Engage Students in Mathematics", *Current Issues in Education,* Vol. 14, No. 2.

Rodriguez, P., M. Nussbaum, and L. Dombrovskaia, 2012, "ICT for Education: A Conceptual Framework for the Sustainable Adoption of Technology-Enhanced Learning Environments in Schools", *Technology, Pedagogy and Education,* Vol. 21, No. 3, pp. 291-315.

Smith, G.S. and J. Hardman, 2014, "The Impact of Computer and Mathematics Software Usage on Performance of School Leavers in The Western Cape Province of South Africa: A Comparative Analysis", *International Journal of Education and Development using Information and Communication Technology,* Vol. 10, No. 1, pp. 22-40.

Song, H. and T. Kang, 2012, "Evaluating the Impacts of ICT Use: A Multi-Level Analysis with Hierarchical Linear Modeling", *Turkish Online Journal of Educational Technology - TOJET,* Vol. 11, No. 4, pp. 132-140.

Thomson, S., L. De Bortoli, and Australian Council for, E.R., 2007, “PISA 2003 Australia: ICT Use Familiarity at School and Home”, *ACER Research Monograph Number 62*, Australian Council for Educational Research.

Thorvaldsen, S., L. Vavik, and G. Salomon, 2012, "The Use of ICT Tools in Mathematics: A Case-Control Study of Best Practice in 9th Grade Classrooms", *Scandinavian Journal of Educational Research,* Vol. 56, No. 2, pp. 213-228.

Vigdor, J.L., H.F. Ladd, and Urban Institute, National Center for Analysis of Longitudinal Data in Education Research, 2010, *Scaling the Digital Divide: Home Computer Technology and Student Achievement. Working Paper 48*, National Center for Analysis of Longitudinal Data in Education Research.

Willms, J.D. and B.A. Corbett, 2012, "Information and Communication Technology: Access and Use [2000 data]", *Education Quarterly Review,* Vol. 8, No. 4.

Wittwer, J. and M. Senkbeil, 2008, "Is Students' Computer Use at Home Related to Their Mathematical Performance at School", Computers *& Education,* Vol. 50, No. 4, pp. 1558-1571.

Ziya, E., N. Dogan, and H. Kelecioglu, 2010, "What Is the Predict Level of Which Computer Using Skills Measured in PISA for Achievement in Mathematics", *Turkish Online Journal of Educational Technology - TOJET,* Vol. 9, No. 4, pp. 185-191.