The Effects of ICT on Achievement: Criticizing the Exclusion of ICT from World Bank's Education Sector Strategy 2020

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ABSTRACT

If there are areas that have received significant impacts of ICTs, education is one of them as ICTs have stimulated major differences in the teaching approaches and the ways students learn (Yuen, Law, & Wong, 2003); however, World Bank unexpectedly excludes ICT from the key focus areas in their ESS 2020, a guideline that may be adopted by developing countries for improving national education policies and agendas. Thus, by using hierarchical linear modeling and the latest PISA results, the present study examines the effects of student's use of ICT and school's resources on achievement in the third world countries. The analyses disclosed that (1) students' frequencies of ICT use outside of school as well as at home were negatively related to student achievement, (2) school's resources were positively related to student achievement on science at school level and cross-level interactions, (3) the availability of ICT for students to use at school was also significantly associated with student achievement. The exclusion of ICT from World Bank ESS 2020 does not show that ICT no longer plays significant role in student learning process and no longer has a positive effect on student achievement; rather, ICT is probably falling out of favor because of the litigation surrounding it nowadays (McGrath, 2012).

Keywords: effects of student's use of ICT, school's resources, World Bank ESS 2020, PISA

INTRODUCTION

The present study examines the effects of student's use of ICT and school's resources on achievement in the third world countries. It is driven by fact that the World Bank's Education Sector Strategy (ESS) 2020 does not include ICT in Education as one of the key ideas. Meanwhile, in their previous policy documents, World Bank had always included ICT for education and played vital leadership and active involvement with regards to ICT in education (McGrath, 2012). Such a significant change raises a question if ICT still plays a significant role for student learning and still has a positive effect on student achievement in the present day. By using the latest results of Programme for International Student Assessment (PISA), this study specifically looks at the third world countries, given that the ESS 2020 is used to lay out the World Bank Group's agenda for achieving *learning for all* in the developing world (World Bank, 2011).

Despite the view of the effectiveness of ICT as a means for accommodating educational needs, goals, and requirements (Gumus & Atalmis, 2011) and the growing interests from both education policy makers and researchers in the positive effects of ICT use on student development (Aypay, 2010; Gumus & Atalmis, 2011; Ponzo, 2010), a review of 102 studies of the effects of ICT on achievement shows that most of earlier studies are more focused on the improvement on student attainment measured by using secondary or indirect variables, for example motivation, concentration, cognitive processing, critical thinking, and reading comprehension (McFarlane, Harrison, Somekh, Scrimshaw, Harrison, & Lewin, 2000). This indicates that studies focusing on the effects of ICT use on student achievement measured by international standardized tests in the context of developing countries can contribute to the literature.

Discussing the effects of ICT on achievement with the relation to the World Bank's ESS 2020 can potentially stimulate the emergence of a new understanding of the role of ICT in education. In the ESS 2020, World Bank mentions ICT roles in changing job profiles and skills demanded by labor markets, and admits that ICT offers possibilities for accelerated learning and improved management of education systems. However, these are the only insightful explanations they made on ICT in education and it is only in one sentence in a 112-page document. The other two sentences of ICT in the ESS 2020 are more focused on ICT as a powerful tool for accountability and system monitoring rather than on assisting student learning process and improving student achievement. It is very contradictory with the World Bank's core objective, which is to help countries improve learning, and with their jargon *investing smartly*, that prioritize learning and skills development. Besides, since launched in 2011, the 2020 World Bank Education Sector Strategy (ESS) *learning for all* has received some critiques for leaving out several important points in education, such as right to education (Klees, 2012), teacher learning (Ginsburg, 2012), the misleading definition of quality in education (Soudien, 2012), and ICT (McGrath, 2012). The ESS 2020 is entitled *learning for all*, but it provides a little explanation about learning (Samoff, 2012).

If there are areas that have received significant impacts of ICTs, education is one of them as ICTs have stimulated major differences in the teaching approaches and the ways students learn (Yuen, Law, & Wong, 2003); however, World Bank unexpectedly excludes ICT from the key focus areas in their ESS 2020, a guideline that may be adopted by developing countries in improving national education policies and agendas. Considering such circumstances, this paper, hence, seeks for the latest empirical evidence on the effects of student's use of ICT and school's resources on achievement in the third world countries and relates the findings with the World Bank's disregard on the role of ICT in ESS 2020.

Student's Use of ICT and Achievement

A study on the relationship between students' performance in England on national tests and their reported use of ICT that involved 1100 children sampled from 27 primary and 28 secondary schools found that individual use of ICT appeared to be a significant determinant on student performance (Harrison, Lunzer, Tymms, Fitz-Gibbon, & Restorick, 2004). Another study using large-scale international databases including TIMSS 2011, PIRLS 2011, and PISA 2012 discovered that, holding constant the national economic development level, the national ICT development level was a significant positive predictor for student academic achievement in reading, mathematics, and science; besides, individual-level ICT use was a significant predictor, yet its influence was mixed across student groups and subjects following the ICT usage type (Skryabin, Zhang, Liu, & Zhang, 2015).

The levels of students' familiarity with ICT and their exposure to technology can be used to explain the achievement gaps between individuals and schools in Turkey based on the 2009 PISA result (Delen & Bulut, 2011). Among Czech students, it was also found that student who were exposed to ICT achieved better scores on science knowledge test than students who were not (Kubiatko & Vlckova, 2010). Nevertheless, the findings from Papanastasiou, Zembylas, & Vrasidas' study (2003) suggests that it is the way in which computers are used that influences student science achievement as their study shows a negative relationship between the use of certain types of educational software and student achievement among the U.S. students participating in PISA 2000.

Regarding school's resources of ICT and student achievement, significant differences were found between high and low socio-economic status (SES) schools because of different levels of access to software, student use of software, and technology supports (Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008; Wastiau et al., 2013). ICT implementation in school is largely influenced by the school leader's vision and understanding of the role and impact of ICT in the curriculum (Yuen, Law, & Wong, 2003). In Kozma'z study (2003) about technology and classroom practices in 28 countries, it was found that technological tools and resources in school assisted students in searching for information, designing products, and publish results.

School can be designed to be technology based learning environment, which can effectively improve student achievement in learning English as a foreign language. Hussain, Niwaz, Zaman, Dahar, & Akhtar, (2010) conducted an experimental study with 90 students of 10^{th} grade of a public school in Islamabad, Pakistan. The performance of the experimental group showed the enhancement of the student achievement level in English. High use of computer for learning mathematics could also reduce a gap in math achievement between English-speaking groups and English language Learners; specifically, when Hispanic and Asian students used computers for math more frequently, they showed high math performances compared to their English-speaking counterparts (Kim & Chang, 2010). Nevertheless, a different result was obtained by Carrillo, Onofa, & Ponce (2011). Studying the effects of ICT on student achievement in schools in Ecuador, they discovered that the ICT program only had a positive impact on students' mathematics test scores, not on students' language test scores.

Student's use of technological devices outside of the school or at home potentially influences student achievement at school. Battle (1999) studied home computers and school performance and suggests that having access to computers at home can account for the differences in educational gains and student performance at school based on socio-economic status, gender, and race/ ethnicity. The positive effect of the frequency of computer use on the improvement student science score in PISA 2006 happened to be larger to students who more frequently use computers at home than at school (Spiezia, 2011), yet a television-rich parental home could be disadvantageous for student performance in science (Notten & Kraaykamp, 2009).

About the influence of home internet use on low-income student's academic performance, Jackson, Von Eye, & Biocca (2003) found that the more frequently the students used the internet at home, the better their GPAs and standardized test scores became. Students who utilized computers for one hour per day display positive school behaviors and higher math and reading test scores (Lee, Brescia, & Kissinger, 2009). It seems that the availability of technological devices at home is essential as students can utilize them as learning tools aimed at improving academic skills and performance (Corbett & Willms, 2002). However, other studies found negative impacts on student achievement. Wittwer & Senkbeil (2008) examine whether students' computer use at home is related to their mathematical performance at school. By using the data of German students in PISA 2003, the study confirmed no link between students' access to a computer and their frequency use of computer at home with their mathematical performances. The positive effect was only observed in a small group of students who utilized the computer for problem-solving activities. The availability of technological devices at home can distract students from effective learning (Woessmann & Fuchs, 2004; Aypay, 2010).

World Bank in Educational Development

The World Bank has been one of the key actors in educational development. It is the largest funder of education for developing countries and has the capacity, power, and resources in coordinating global initiatives following its global agenda (Mundy, 2002). The bank is equipped with financial, political, and technical power and capacity for setting and spreading its global agenda for development (Tarabini, 2007). Essentially, the bank's participation in education is framed by its belief that education is tied to reduction of poverty, in which knowledge is considered as a means of improving one's understanding of and position in society (Stromquist, 2012). It endorses human capital theory that assumes," …. investment in education will have positive effects on human skills and worker productivity, effects that will bring benefits both individually (higher income, the acquisition of status) and socially (economic growth, technological progress and collective well-being)" (Bonal, 2007, p. 3). In other words, any individual should use educational opportunities to develop their innate abilities and invest in themselves; in the future, such knowledge and skills obtained through educational processes will benefit their life socially and economically. However, despite its worldwide priority strategy to fight poverty, the need to reduce inequality is not explicitly stated in its objectives (Tarabini, 2001) and it targets the poor with the reason to seek to diminish inequality, but then its policies create distinctions between "deserving poor" and non-deserving poor" (Bonal, 2007).

Since its lending for education started in 1962, World Bank has published several policy documents and statements in 1963, 1971, 1974, 1980, 1995, and 2011, that outline its views on educational development, particularly in developing country. Jones (1997) notes that each of these policy documents and statements serves particular purposes, but at least there are two rationales underlining these publications: (1) the publications of the policy documents give the bank an opportunity to deliver its thoughts about education and development, through which the bank expects that governments, multilateral and bilateral aid agencies, and academic communities will be convinced by its views and will adopt them, (2) the publications are the place where the bank publicizes its own priorities for lending. As the bank's visions about development are related to the extent of participation and integration with the global market (Munck, 1999), its views and solutions in education always have a connection to," … the decentralization of management of public education, the expansion of the private sector, and the application of cost recovery in higher education" (Jones in Stromquist, 2012, p. 2).

World Bank's participation in educational development is evident in developing countries. For instance, based on the evaluation report by Bender, Diarra, Edoh, & Ziegler, (2007), the bank gave assistance to primary education in Mali from 1990 to 2005, improving services, such as curriculum development, teacher training and education, teacher hiring, public-private partnership for service delivery, the use of national languages, curriculum reform, statistics, and text book policy. Malian children have a very poor life, about 239 children per 1,000 died before reaching age five and 83% of children suffered from anemia. The report explains:

> The World Bank was very active in Mali during this time, approving a total of 78 IDA credits. Assistance to education was continuous and provided through three distinct approaches: (i) financial assistance, including structural adjustment credits, the Heavily Indebted Poor Country trust fund (HIPC), and Poverty Reduction Support Credits (PRSC); (ii) education policy initiatives ranging from home-grown policies such as ruralization, the "New Primary School" program (*Nouvelle Ecole Fondamentale* (NEF)), and the Ten-Year Education Development Program (*Programme Décennal de l'Education* (PRODEC)) to international initiatives such as Education For All (EFA); and (iii) direct investment in discrete elements such as teachers, curriculum, infrastructure and textbooks (Bender, Diarra, Edoh, & Ziegler, 2007, p. ix).

Nonetheless, the report concludes that despite its huge contribution in finance and policy change, the quality of bank intervention was inconsistent and had negative effects. This evaluation report can be one of the examples that stimulates some critiques regarding World Bank's priorities and strategies for education. The bank has been criticized for its assumptions of the benefits of schooling, its approaches to basic schooling and basic skills, its view of pedagogic professionalism, its view of decentralization in education, its focus on rate of return, and its assumption of protecting the poor by raising fees (Bennell, 1996; Burnett, 1996; Lauglo, 1996). The bank's consistency in institution's policies and practices on education is also questioned, since World Bank's education policy swings over time and the multi-agency Education for all initiative is unrealistic and unreachable (Psacharopoulos, 2006; Samoff, 1996). Table 1 provides the information of the changes in the bank's education policy over time and table 2 explains the bank's major education policy-related events.

Table 1. World Bank education policy swings over time

1945–1963	No policy
1963–1987	Manpower, VOCED oriented
1987–1990	Internal debates, confused
1990–1997	Basic, general education oriented
1997-present	No clear priorities

(*Source*. Psacharopoulos, 2006)

Table 2. A chronology of major education policy-related events at the World Bank

1945	Bank starts operations
1962	President's first memo on education policy
1963	First education loan
1967	Professor Blaug's white paper
1970	President's second memo on education policy
1972	Education sector policy statement
1980	First policy paper on education
1985	Three key research outputs: Rates of return review article Education for development book Diversified secondary education book
1986	The financing education paper
1990	Primary education policy paper Jom tien conference: education for all
1991	VOCED policy paper
1992	Another key research ouput: software inputs vs. bricks and mortar
1994	Higher education: a review of experience
1995	Priorities and strategies in education: a review paper
1999	Education sector strategy
2011	Education Sector Strategy 2020 (added)

(*Source*. Psacharopoulos, 2006)

Burnett and Patrinos (1996) respond to the critiques of World Bank's priorities and strategies for education by emphasizing several points. First, they admit that World Bank's approach in education relies on the academic and policy-oriented economic literature, thereby accepting human capital perspective. Second, World Bank is focused on outcomes of education, given that education is about learning and fulfilling people's demands, helping them become more productive (investment) or enjoy life (consumption). Third, World Bank is naturally concerned with poverty reduction and empowering the poor by improving their productivity is the bank's primary goal in education. These responses substantially clarify key points with regard to World Bank's participation in educational development. Nevertheless, it is also important to underline that as projects and funding continue, aid agencies, such as World Bank, are continuing to instruct more than listen, which can undermine the dialogue and partnership they claim to construct, particularly in developing countries (Ashford & Biswas, 2010); Samoff, 2004; Smith, 2005).

ESS 2020, ICT, and Rationale for the Study

In 2011, the World Bank launched its new Education Sector Strategy entitled *Learning for All, Investing in People's Knowledge and Skills to Promote Development*, a goal that is set up to be achieved in the next decade – approximately in 2020. As shown in Table 2 about a chronology of major education related events at the World Bank, the bank began to use *education sector strategy* in 1999 and was continued to be used in 2011. Before 1999, the bank had published several policy documents or statements related to its visions in educational development. Education is one of the main key areas used by the World Bank for realizing its goals in poverty reduction and development, particularly in the developing countries, because the path in education has been parallel with its belief in usefulness of knowledge and skills for improving one's life (Jones, 1997).

Regarding the World Bank's policy documents in educational development and ICT, it is important to see that while its primary focus on helping and improving educational development in developing countries does not change over time, it has reduced its focus on utilizing ICT for improving outcomes of education, especially in the context of ICT for assisting student learning process and improving student achievement. The bank's documents published in 1995 and 1999 put high emphasis on the use of technology in supporting and improving learning process. Nevertheless, despite the swift development and integration of ICT in education worldwide nowadays, the bank's ESS 2020 barely discusses ICT with no mention of virtual schools or distance learning; instead, it contains a single, ambivalent reference to ICT for education (McGrath, 2012).

In the World Bank's document *Priorities and Strategies for Education* published in 1995, technology development was considered as one significant factor influencing educational outcomes and economic growth (World Bank, 1995). Technology was discussed intensively and mentioned almost in every page of the document, including the increase of the technology content of general and vocation education in East Asian countries and members of the OECD (the Organization for the Economic Co-operation and Development), the substantial uses of technology in realizing learning objectives, tools and technology for learning, and the idea of correspondence courses and open universities for increasing cost-effectiveness.

The use of technology for education was continued to be discussed intensively in World Bank ESS 1999 entitled *The Vision: Quality of Education for All.* Technology was included into one of the key strategies in improving the quality of teaching and learning, highlighting distance education, open learning, and the use of new technologies (World Bank, 1999). The bank elaborated the implementation plan for improving education in developing countries by using technology, such as establishing worldwide network of science and technology educators, developing an education technology strategy, and so forth. Nevertheless, ESS 2020 surprisingly excludes technology from its key strategies for improving education in developing countries, although research on ICT and education has increased since the last decade and the term *ICT* (Information and Communications Technology) has been used worldwide.

At this point, inquiries about the rationales behind the exclusion of ICT from the World Bank ESS 2020 and the latest roles and effects of ICT on improving education and achieving learning objectives in developing countries are necessary. Moonen, J. (2008) says:

> In general, the higher the economic level in a region the more that an explicit policy focus on IT and education is fading. Using IT in education is becoming more implicit and incorporated in a broader policy context, especially around needed qualifications and competencies of citizens in a knowledge society. There is a lack of convincing evaluation and assessment results that show the impact of the policies. Perhaps it will only be when both informal and formal learning are considered that the potential of IT for the transformation of learning will be achieved (p. 1).

The exclusion of ICT from ESS 2020 may be based on one of or these two reasons: (1) because of the many enabling roles for ICT in education, it no longer needs to be discussed explicitly in policy documents, (2) or, ICT is probably falling out of favor because of the litigation surrounding it nowadays (McGrath, 2012).

However, examining at how ICT use and role in improving learning process and student achievement in developing countries in the present day may potentially provide some insights about whether it is still essential including ICT in policy documents with regard to improving education in the third world countries. A number of studies have elaborated and explored how ICT can support the learning process (Lai, 2008). Nonetheless, are the findings of earlier studies still relevant to the current situation in developing countries? How do student's use of ICT and school resources of ICT help improve student achievement? How do the effects of student's use of ICT and school resources of ICT vary among developing countries? As PISA is supported by the World Bank and PISA is argued to evaluate education systems worldwide by testing student's skills and knowledge, it is important to see how student's use of ICT and school resources of ICT are related to student achievement in the latest PISA result and answer these questions.

RESEARCH METHOD

Data

This study employs a quantitative research design, aimed at quantifying relationships and the subjects are not intervened (Hopkins, 2008). It uses the data of PISA 2015, specifically on student's frequency of ICT use at school and outside of school, the availability of ICT for students to use at school and at home, school's resources and student achievement in science. The focus is on examining the effects of student's use of ICT and school resources in developing countries that participated in PISA 2015. The country classification provided by the United Nations (2012) is used as the reference. Initially, this study attempted to examine eighteen developing countries, including Argentina, Brazil, Chile, Colombia, Costa Rica, Hong Kong SAR, Indonesia, Israel, Jordan, Malaysia, Mexico, Peru, Qatar, Thailand, Tunisia, United Arab Emirates, Viet Nam, and Uruguay. However, unfortunately, after doing some data cleaning, it was found that there are only a few of the developing countries in which their students participated in the ICT familiarity questionnaire of PISA 2015. Although there are thousands of students participating in PISA test in 2015, it seems that only one or two hundreds of students participated in the ICT familiarity questionnaire. Besides, not all the available data from developing countries are appropriate for a multilevel analysis due to inadequate number of data.

Hence, based on the available data for a multilevel analysis, four developing countries were chosen for this study: Chile, Thailand, Brazil, and Colombia. Table 3 below provides descriptive statistics of the characteristic of the four countries in each level of analyses.

Table 3 . Descriptive statistics of the subjects

Level 1					
	Availability of ICT (Mean/ SD)		Student's frequency of ICT use (Mean/ SD)		N of student
	At home	At school	Outside of school	Home	
Chile	20.47/ 4.24	21.64/ 4.56	26.30/ 10.72	16.64/ 7.34	158
Thailand	19.94/ 5.42	17.44/ 4.98	33.37/ 10.15	22.52/ 7.96	254
Brazil	20.80/ 6.08	21.73/ 6.14	26.56/ 13.33	15.29/ 7.83	190
Colombia	20.48/ 4.95	18.46/ 4.78	34.73/ 11.88	19.96/ 8.87	245

Level 2		
	School's resources of ICT (Mean/ SD)	N of School
Chile	591.29/ 453.33	7
Thailand	723.00/ 678.11	9

Brazil	329.36/ 318.05	14
Colombia	397.23/ 343.01	13

Data Analysis

Variables

This study used individual-level and school-level variables nested in country. Individual level variables include ICT availability at home, ICT availability at school, frequency of ICT use outside of school, frequency of ICT use at school, and student's science scores, while school level variable is school's resources of ICT.

ICT availability at home. This variable assesses what devices are available for students to use at home and whether students use the available devices if they exist at home. The question given for this variable is "Are any of these devices available for you to use at home?." It is applied to eleven items that consist of various devices, such as desktop computer, portable laptop or notebook, tablet computer, internet connection, cell phone, e-book reader, portable music player, and so forth. Responses range from 1 to 3, where "1" = "Yes, and I use it", "2" = "Yes, but I don't use it", and "3" = "No". The Cronbach's alpha is .720, which expresses high internal consistency (Mean = 18.53 and SD = 4.365).

ICT availability at school. This variable evaluates what devices are available for students to use at school and whether students use the available devices if they exist at school. The question given for this variable is "Are any of these devices available for you to use at school?." It is applied to ten items that include various devices, such as desktop computer, portable laptop, internet connected school computers, interactive whiteboards, and so forth. Responses range from 1 to 3, where "1" = "Yes, and I use it", "2" = "Yes, but I don't use it", and "3" = "No". The Cronbach's alpha is .768, which expresses high internal consistency (Mean = 19.96 and SD = 4.648)

Frequency of ICT use outside of school. This variable is aimed to explore student's frequency of ICT use outside of school. The question used to assess this variable is "How often do you use digital devices for the following activities outside of school?". It is applied to twelve kinds of activities, such as browsing the internet for schoolwork, browsing the internet to follow up lessons, using e-mail for communication with other students, using e-mail for communication with teachers, and others. The options range from 1 to 5, in which "1" = "Never or hardly ever", "2" = Once or twice a month", "3" = "Once or twice a week, 4" = Almost every day, "5" = "Every day." The Cronbach's alpha is .917, which shows very high internal consistency (Mean = 27.20 and SD = 10.882).

Frequency of ICT use at school. This variable is intended to collect information about student's frequency of ICT use at school. The question is "How often do you use digital devices for the following activities at school?". It is applied to nine items that involve various activities, for example chatting online at school, using e-mail at school, browsing the internet for schoolwork, etc. The options range from 1 to 5, in which "1" = "Never or hardly ever", "2" = Once or twice a month", "3" = "Once or twice a week, 4" = Almost every day, "5" = "Every day." The Cronbach's alpha is .896, which shows very high internal consistency (Mean = 17.03 and SD = 7.869).

Students' science scores. Students' scores in science in PISA 2015 is used as dependent variable in this study.

School's resources of ICT. This variable gathers information about the student-computer ratio for students that indicate school's resources of ICT. The questions, for example, are "At your school, what is the total number of students in the national modal grade for 15-year old?, Approximately, how many computers are available for these students for educational purposes?, Approximately, how many of these computers are connected to the internet?, and others." Responses are in number. The Cronbach's alpha is .796, which shows high internal consistency (Mean = 437.44 and SD = 576.262).

Multicollinearity and Outliers

Since too high correlated independent variables with each other can be problematic in regression analysis, multicollinearity diagnostics was conducted in this study. First, the independent variables were examined by using correlation and the correlation matrix showed that none of the variables has Pearson correlation higher than .6. It is considered problematic if the Pearson correlation is more than .6 (Lutz, 2011). Then, multicollinearity was carried out to see the variance inflation factor (VIF). VIF > 5 is used to see if the correlations are too high (Studentmund, 2001). The result revealed that no variable has VIF more 5, meaning that the variables are not problematic when used in regression analysis, as seen in Table 3.

Table 4. Multicollinearity diagnostic for the variables used in this study

	Unstandardized Coefficients				Collinearity Statistics	
Variables	B	Std. Error	t	Sig.	Tolerance	VIF
Sch_Resource	.016	.002	9.527	.000	.998	1.002
Freq_ICTUse_ OutsideSchool	-.713	.110	-6.507	.000	.647	1.545
Freq_ICTUse_ AtSchool	-.662	.154	-4.291	.000	.622	1.608
Avai_ICT_for_ Use_AtSchool	1.669	.227	7.360	.000	.777	1.287
Avai_ICT_for_ Use_AtHome	-3.820	.243	-15.742	.000	.815	1.227

Dependent Variable: Plausible Value 1 in Science

In addition, outliers were detected by using Studentized Residual and Cook's D. The range for Studentized Residual is between -2 and +2, while the values should not be more than +1 for Cook's D. To minimize the effects of outliers in the statistical analysis, any individuals that showed the value more than these ranges were deleted from the data.

Hierarchical Linear Modeling and Model of the Study

The present study utilizes Hierarchical Linear Modeling (HLM) to analyze the individual-level and school-level variable nested in country. HLM is recommended to analyze nested data and has been widely used to predict a dependent variable on the condition where independent variables are derived from different levels examining the dynamic between micro- and macro-levels (Raudenbush, 2002).

In this study, five hypotheses were created: (1) availability of ICT for students to use at home is related to their achievement in PISA, (2) availability of ICT for students to use at school is related to their achievement in PISA, (3) student's frequency of ICT use outside of school is related to their achievement in PISA, (4) student's frequency of ICT use at school is related to their achievement in PISA, (5) school's resources of ICT are positively associated with student achievement in PISA, and (6) availability of ICT for students to use at home and school, student's frequency of ICT use outside of school and at school, and school's resources, all together, are positively associated with student achievement in developing countries. Based on these hypotheses, two levels were created as shown in the following figure:

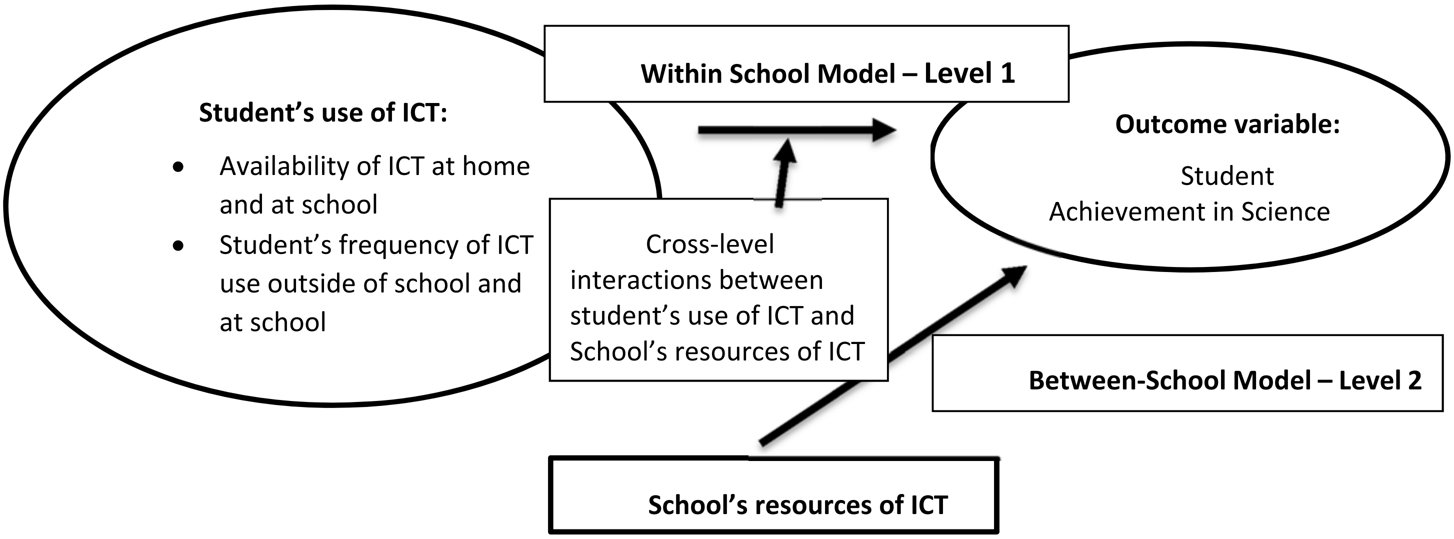

Figure 1. Multilevel model of the effects of student's use of ICT and school's resources of ICT on achievement

RESULTS

Unconditional Models

First, the fully unconditional model with no predictors for student achievement on science was run to see if the achievements varied by school and if there was sufficient variance in science achievement at Level 2 for each country. From the result of this model, Intraclass Correlation was calculated by using the following formula:

Intraclass correlation (ICC): $\tau_{00} / \tau_{00} + \sigma^2$ =

Where:

τ_{00} = Between group variance

σ^2 = Within Group variance

Chile. Between group variance is 1440.14 and Within group variance is 2971.84, so ICC is .33 (χ^2 = 73.55, $p < .001$), which means that 33% of the variability in student achievement in science can be significantly explained by group differences or occurs between schools.

Thailand. The result of the ICC calculation from between group variance = 7658.81 and within group variance = 3824.68 is .67 (χ^2 = 460.64, $p < .001$), showing that 67% of the variability in student achievement can be significantly explained by group differences or occurs between schools.

Brazil. The obtained between group variance is 3768.10 and within group variance is 3937.53; thus, ICC is .49 (χ^2 = 225.71, $p < .001$), meaning that 49% of the variability in the outcome variable can be significantly described by group differences or occurs between schools.

Colombia. As τ_{00} = 581.50 and σ^2 = 4129.65, the ICC is .12 (χ^2 = 41.84, $p < .001$). It shows that 12% of the variability in the outcome variable can be significantly elaborated by group differences or occurs between schools.

The results of the fully unconditional models in the four countries indicate that students' scores on science are dependent on group differences, not only on differences among individual; thus, it is important that hierarchical linear modeling is employed to estimate the regression components.

Level-1: Within-School Model of Student Achievement

In level 1 models, availability of ICT for students to use at home and school, and student's frequency of ICT use outside of school and at school were entered as predictors for student achievement. By using the independent variables in Level 1, the formula is shown below:

$$PV1SCIE_{ij} = \beta_{0j} + \beta_{1j}*(\text{Avai\_ICT\_Hom}_{ij}) + \beta_{2j}*(\text{Avai\_ICT\_Sch}_{ij}) + \beta_{3j}*(\text{Fre\_ICT\_Out}_{ij}) + \beta_{4j}*(\text{Fre\_ICT\_Sch}_{ij}) + r_{ij}$$

Then, to calculate a measure of effect size, the variance (r^2) explained by the level-1 predictor variable in the outcome variable was calculated, as seen in the following formula:

$$r^2 = (\sigma^2_{null} - \sigma^2_{random}) / \sigma^2_{null}$$

Chile. The results of the analysis showed that the intercept for the independent variables was statistically significant with the coefficient 454.88 and $p < .001$. Student's frequency of ICT use outside of school was negatively related to student achievement (Coefficient = -1.85, SE = .22) and statistically significant ($p < .001$), while availability of ICT for students to use at home and school, and student's frequency of ICT use at school were not significantly related to student achievement. The reliability estimate was .88 with the intersect of variance components for random effects at 1139.66, which was statistically significant at $p < .001$. The coefficient of level 1 residual was 2601.27. From the calculation of a measure of effect size, it was obtained that Level-1 models in Chile for student achievement accounted for only 11% of the within school models variance in the outcome variable.

Thailand. The results revealed the significance of the intercept for the independent variables (Coefficient = 446.67, SE = 29.20, $p < .001$). Of the four predictors, availability of ICT for students to use at school was positively related to student achievement and statistically significant (Coefficient = 1.91, SE = .93, $p = .04$). The reliability estimate was .98 with the intersect of variance components for random effects at 8606.47, which was statistically significant at $p < .001$. The coefficient of level 1 residual was 3712.21. Level-1 models in Thailand for student achievement accounted for only 3% of the within school models variance in the outcome variable.

Brazil. The analysis showed the significance of the intercept for the independent variables (Coefficient = 391.89, SE = 16.67, $p < .001$); however, none of the predictors was significantly related to student achievement. The reliability estimate was .87 with the intersect of variance components for random effects at 3516.94, which was statistically significant at $p < .001$. The coefficient of level 1 residual was 3978.37. Level-1 models in Brazil for student achievement accounted for only 1% of the within school models variance in the outcome variable.

Colombia. The results disclosed that the intercept for the independent variables was statistically significant with the coefficient 419.21 and $p < .001$. Student's frequency of ICT use at school was negatively related to student achievement (Coefficient = -1.95) and statistically significant ($p < .001$). On the other hand, the other three predictors were not significantly correlated with student achievement. The reliability estimate was .59 with the intersect of variance components for random effects at 395.93, which was statistically significant at $p < .001$. The coefficient of level 1 residual was 4006.05. From the calculation of a measure of effect size, it was obtained that Level-1 models in Colombia for student achievement accounted for only 3% of the within school models variance in the outcome variable. Table 4 below summarizes the information resulting from Level-1 models for each country.

Table 5. Level 1 – Within-School Models of Student Outcomes

	Student Achievement on Science			
Effects	**Coefficient/ SE**			
	Chile	**Thailand**	**Brazil**	**Colombia**
Fixed effects				
Intercept	454.88/ 12.55*	446.67/ 29.20*	391.89/ 16.67*	419.21/ 6.84*
Avai_ICT_Hom	-2.11/ 1.28	.76/ 1.10	-1.05/ 1.45	.21/ .71
Avai_ICT_Sch	1.21/1.45	1.91/ .93***	1.15/ 1.97	.86/ .86
Fre_ICT_Out	-1.85/.22*	-.11/ .36	.33/ .29	.73/ .44
Fre_ICT_Sch	-.54/ .37	1.05/ .68	-.70/ .84	-1.95/ .56*
	Variance component			
Variance components for random effects				
Intercept (τ_{00})	1139.66*	8606.47*	3516.94*	395.93***
level-1, *r*	2601.27	3712.21	3978.37	4006.05

*** p < .001, ** p < .01, ***p < .05**

Level-2: Between-School Model of Student Achievement

In Level-2 models, first, school's resources were entered as predictor for student achievement. Then, a mixed model that combines all predictors at Level-1 models and Level-2 model were run to see cross-level interactions. The equations are explained below:

(1) $\beta_{0j} = \gamma_{00} + \gamma_{01}*(School\_Res\_ICT_j) + u_{0j}$

(2) $PV1SCIE_{ij} = \gamma_{00} + \gamma_{01}*\text{Avai\_ICT\_Hom}_j$
$+ \gamma_{10}*\text{Avai\_ICT\_Sch}_{ij}$
$+ \gamma_{20}*\text{Fre\_ICT\_Out}_{ij}$
$+ \gamma_{30}*\text{Fre\_ICT\_Sch}_{ij}$
$+ \gamma_{40}*\text{School\_Res\_ICT}_{ij}$
$+ u_{0j} + r_{ij}$

The results of the analyses of Level-2 models indicated that school's resources were positively related to student achievement and statistically significant in Brazil (Coefficient = .10, SE = .03, p = .009). Nevertheless, school's resources were not significantly related to student achievement in Chile, Thailand, and Colombia. The intercept of the predictor was significant with p < .001. The detailed information is provided in table 5 below.

Table 6. Level 2 – Between-School Models of Student Outcomes

	Student Achievement on Science			
Effects	**Coefficient/ SE**			
	Chile	**Thailand**	**Brazil**	**Colombia**
Fixed effects				
Intercept	450.14/ 12.51*	447.54/ 26.71*	389.80/ 14.57*	417.46/ 7.62*
School_Res_ICT	-. 04/ .02	-.04/ .04	.10/ .03**	.02/ .02

Cross-Level Interactions

Intercept	454.62/12.42*	446.47/ 27.97*	390.65/ 13.81*	418.45/ 7.23*
Avai_ICT_Hom	-2.10/ 1.27	.74/ 1.10	-1.19/ .03	.30/ .72
Avai_ICT_Sch	1.50/ 1.27	1.93/ .94***	1.32/ 1.99	.83/ .85
Fre_ICT_Out	-1.83/ .32*	-.12/ .36	.30/ .29	.68/ .43
Fre_ICT_Sch	-.50/ .43	1.07/ .69	-.77/ .81	-1.87/ .51*
School_Res_ICT	-.01/ .02	-.04/ .04	.11/ .03**	.01/ .02
Variance component				
Variance components for random effects				
Intercept (τ_{00})	1302.55*	9020.40	2559.76*	475.72*
level-1, *r*	2604.31	3711.84	3973.79	3995.08

*** p < .001, ** p < .01, ***p < .05**

On cross-level interactions, availability of ICT for students to use at school was positively related to student achievement and statistically significant in Thailand (Coefficient = 1.93, SE = .94, p = .04). Similarly, school's resources were significantly correlated with student achievement in Brazil (Coefficient = .11, SE = .03, p = .008). In contrast, two other predictors, students' frequency of ICT use outside of school in Chile and student's frequency of ICT use at school in Colombia were negatively related to student achievement and statistically significant; the coefficients are -1.83 (SE = .32, p < .001) and -1.87 (SE = .51, p < .001) respectively. Nonetheless, other than these variables, the other predictors did not show any significant relationships with student achievement in science.

DISCUSSION AND CONCLUSION

While some studies confirm the positive relationship between student's frequency of ICT use at school and at home with student achievement (Harrison, Lunzer, Tymms, Fitz-Gibbon, & Restorick, 2004; Delen & Bulut, 2011; Kubiatko & Vlckova, 2010), different results were obtained from the present study. The results showed that, both at individual and cross-level interactions, student's frequency of ICT use outside of school as well as at home was negatively related to student achievement. At individual level, student's frequency of ICT use outside of school in Chile and student's frequency of ICT use at school in Colombia were found to be negatively correlated with their student achievement on science in PISA 2015, where the coefficients were -1.85 (p < .001) and -19.5 (p < .001) respectively. At cross-level interactions, the relationships remained negative for Chile and Colombia, in which the coefficients were -1.83 (p < .001) and -1.87 (p < .001) respectively. Meanwhile, student's frequency use of ICT at outside of school and at school did not show any significant relationships in Thailand and Brazil.

These findings of the present study are relevant with the study conducted by Skryabin, Zhang, Liu, & Zhang (2015). They explain that although the national ICT development level is a significant positive predictor for student academic achievement in reading, mathematics, and science, individual-level ICT use is only significant depending on types of student groups and subjects following the ICT usage type. Papanastasiou, Zembylas, & Vrasidas (2003) argue that it is the way in which computers are used that influences student science achievement. This study support the argument that ICT could distract student from learning unless it was used for academic/ school purposes. In this instance, the more frequent students use ICT, the more information and knowledge they can obtain; however, the negative effect may happen if the ICT use is not for academic/ school purposes.

About the effects of school's resources on achievement, positive relationships were found in Brazil. The result of the analysis displayed that school's resources are positively related to student achievement on science with the coefficient .10 and p value = .009 at school level. The same relationship was also discovered at cross-level interaction, where the coefficient was .11 (p = .008). Additionally, the availability of ICT for students to use at school was also significantly associated with student achievement. The evidence was found in Thailand, where the positive association remained the same at individual and cross-level interactions. The coefficient at individual level was 1.91 (p = .04) and was 1.93 (p = .04) at cross-level interactions. The findings sustain the studies confirming the positive effects of school's resources of ICT on achievement (e.g. Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008; Wastiau et al., 2013; Kozma, 2003; Hussain, Niwaz, Zaman, Dahar, & Akhtar, 2010; Kim & Chang, 2010; Carrillo, Onofa, & Ponce, 2011).

With these findings, it is suggested that World Bank should not disregard the effects of ICT in education, especially on student achievement in developing countries. The benefits result from ICT substantially depend on how it is used or for what purpose it is used. Indeed, the availability of ICT for students to use at school and at home does not automatically make their achievement rocketing; instead, they need guidance so that they can get the most advantage of the availability of ICT. Hence, the exclusion of ICT from World Bank ESS 2020 does not show that ICT no longer plays significant role in student learning process and has a positive effect on student achievement.

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