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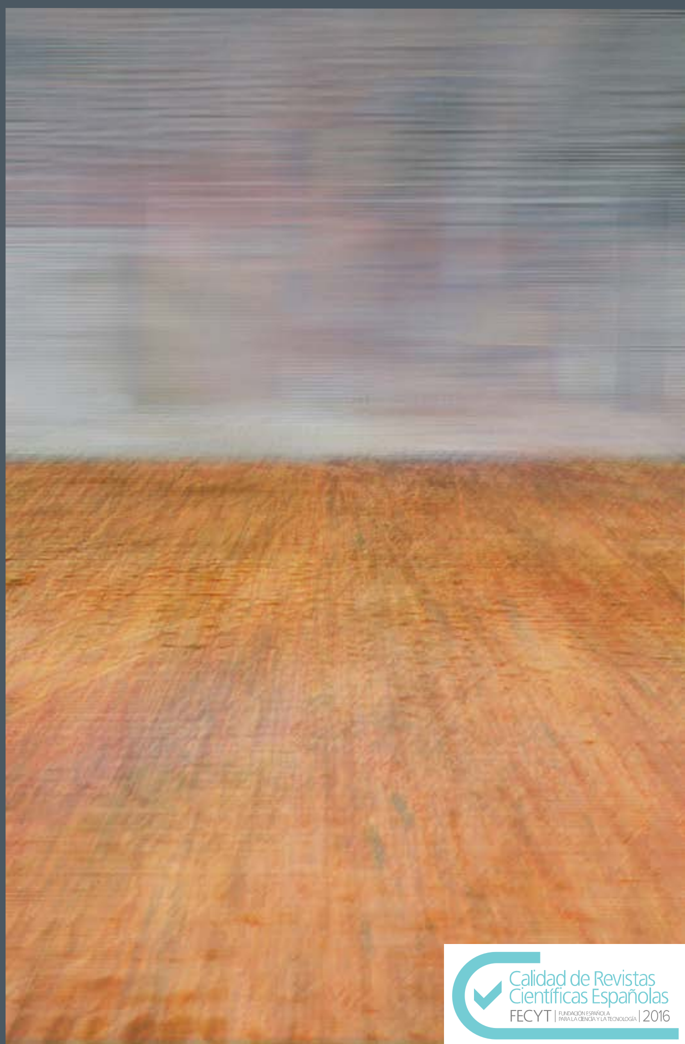

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Acceso a las TIC y rendimiento educativo: ¿una relación potenciada por su uso? Un análisis para España

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Abstract

Information and Communication Technologies (ICT) play a significant role among the educational priorities as they contribute to the student's teaching-learning process. Many studies have examined the relationship between ICT access and use, and the student's learning achievements. However, empirical evidence has not yet been conclusive regarding this issue. The objective of the present paper consists in testing the hypothesis that the relationship between the ICT access and the educational performance is mediated by the ICT use both at home and at school. In particular, we examine if the ICT use reinforces the ICT access effect over the educational outcomes. To achieve this goal, a Structural Equation Model (SEM) is estimated for Spain using data from PISA for the year 2012. Based on the results, ICT access at home has a significant and positive incidence on the educationalperformance, which is fostered by ICT use outside school. In contrast, ICT access and use at school has a significant and negative incidence on the educational performance.

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Keywords: ICT at home, ICT at school, educational performance, teaching-learning process, PISA.

Resumen

Las Tecnologías de la Información y de la Comunicación (TIC) ocupan actualmente un lugar significativo entre las prioridades educativas ya que contribuyen en el proceso de enseñanza-aprendizaje de los estudiantes. Varios estudios han indagado sobre la relación entre el acceso y el uso de las TIC y los logros de los estudiantes en términos de aprendizaje. Sin embargo, la evidencia empírica todavía no es concluyente respecto a esta cuestión. El objetivo del presente trabajo consiste en testear la hipótesis de que la relación entre el acceso a las TIC y el rendimiento educativo se encuentra mediada por el uso de las mismas tanto en el hogar como en la escuela. En particular, se examina si el uso de las TIC potencia el efecto del acceso sobre los logros escolares. Con este fin, se estima para España un Modelo de Ecuaciones Estructurales (SEM) a partir de datos de PISA correspondientes al año 2012. De acuerdo a los resultados obtenidos, el acceso a las TIC en el hogar tiene una incidencia estadísticamente significativa y positiva sobre el rendimiento educativo que se encuentra potenciada por el uso de las TIC fuera de la escuela. Por el contrario, el acceso y el uso de las TIC en la escuela tienen una incidencia estadísticamente significativa y negativa en los logros educativos.

Palabras claves: TIC en el hogar, TIC en la escuela, logros educativos, proceso de enseñanza-aprendizaje, PISA.

Introduction

There is wide agreement about the positive relationship between accumulation of human capital and economic growth (Acemoglu and Autor, 2012). Therefore, the education system of a country can be considered as one of the essential determinants of its growth level. Studying the factors that influence obtaining favorable education goals is crucial in order to carry out sound social and educational policy considerations (Formichella, 2010).

In the last few years, one of the elements that have influenced the educational systems the most is the Information and Communication Technologies (ICT). These technologies currently occupy a very

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significant place among educational priorities due to the fact that they enable contributing to the learning-teaching process of students, among other issues. In this sense, Biagi and Loi (2013) highlight the relevance of ICT as a tool within that process and Rodriguez et al. (2013) analyze how they must be utilized for results to be satisfactory. Thus, the developed economies as well as the developing ones have made massive investments in technological infrastructure and in programs that sustain their utilization (Sunkel and Trucco, 2012). The Spanish educational system has not been alienated fromthis transformation propelled by the ICT.

However, in keeping with what happens in the international literature, there is still no agreement about the causal effect of new technologies onthe educational performance of Spanish students. Some research finds evidence in favor of using computers (Cabras and Tena, 2013) while other studies do not find such positive effects (Calero and Escardibul, 2007); Cordero et al, 2012). In a recent and novel study of the Spanish case, Escardibul and Mediavilla (2015) researchers find that availability of ICT resources (at home as well as at school) affects performancepositively, while the time and frequency of use impact negatively in the acquisition of competencies (regarding Mathematics and reading comprehension).

In the framework, the goal of this paper is to examine if access to ICTs (at home and at school) has a direct effect on the educational performanceand an indirect one by means of the use of ICTs (in and out of school). We shall study, in particular, the effect of access to as well as the use of the ICTs on the educational outcome on Mathematics, language, science measured through the acquisition of competencies in the Program for International Student Assessment, PISA.

This research expects to contribute to the debate around the differential potential effects of the variables associated to ICTs on school achievements initiated by Escardibul and Mediavilla (2015). Unlike existing studies, this paper poses a structure of causal relationships through the Structure Equation Model (SEM), which enables detecting the presence of mediating variables. In the same way, this methodology provides greater flexibility than the regression analysis when assessing relationships between access to ICT, use of ICT and academic performance. Such model applies to data of PISA assessment 2012.

The article is structured in the following way. In the first place, it presents a revision of the literature regarding empirical studies about the topic. Next, the methodology, the data and the variables to be used are detailed. Finally, the results obtained are discussed and the conclusions as well as some considerations of economic policy are presented.

Revision of the literature

The production function of education is usually used as a reference framework for the study of determinants of educational outcomes (Levin 1974; Hanushek, 1979). Such function relates the different resources and consumables that affect students' learning (such as school resources, quality of teachers, classroom size, and family attributes) with the educational outcomes obtained. ICTs, in particular, can be considered as one of the inputs of the production function.

A basic formula of the function can be expressed in the following way:

Educational performance= f(Socioeconomic characteristics of the home, school resources (no ICT), access to ICT; use of ICT)

The literature that has analyzed the relationship between access and use of ICT and students education performanceis broad. However, empirical evidence is disparate and the results obtained are not conclusive. On the one hand, there is a group of studies that find a positive and significant impact of the ICTs on some educational outcomes. On the other hand, some research does not find any effect and, to a lesser degree, some papers find a negative incidence of ICTs on academic achievements.

The main argument of the research of the first group is that new technologies increase flexibility and autonomy of students with regards to learning, and enable an improvement in the attitudes and experiences in teaching-learning. All of that implies an improvement in school performance. Along this line of study are Machin et al. (2007) who, through the use of instrumental variables, provide evidence of the positive causal effect of investment on ICT on educational achievements obtained in English schools at primary level. Banerjee et al. (2007) design a random experiment and find that, in poor urban neighborhoods in India, the use of a learning program assisted by computers has a positive and significant effect on Mathematics outcomes. In the same way, Spieza (2010) analyzes

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the impact of new technologies on academic outcomes of high school students for all countries participating in the PISA 2006. The author concludes that the use of ICT at home has a greater effect than the use of ICT at school and, therefore, he questions the policies directed towards the incorporation of computers in the school environment.

Through a structural equations model, Aristizabal et al. (2009) examine the incidence of ICT at home and at school on the educational performancein Colombia. According to the outcomes, ICTs have a positive effect, their impact being greater at school. On the basis of an experimental design in primary schools in Ecuador, Carrillo et al. (2010) conclude that new technologies have a positive impact on Mathematical outcomes. Cristia et al. (2012) study the impact of the program " One Laptop per child" in Peru and find a positive impact on the general abilities of students in primary schools in the rural sector.

Along the same lines, Botello and Rincon (2014) analyze the data of some countries of Latin America and find that access to Internet in the students' homes improves their average performance, while owning computers do so also and to a greater extent. They also find that the greater the computer ratio per student at school is the better the educational outcomes. In the same way, Mediavilla and Escardibul (2015) study the impact of the ICTs on the educational performance emanating from data of the PISA 2012 for Spain. They conclude that there is a positive effect of technologies on educational achievements, although they highlight that such impact is greater in the field of Mathematics than in the ones of Science or Language. They also clarify that there are differences with regard to which ICT variable is considered.

Formichella et al. (2015) utilize pairing techniques to control the diverse personal, family and school characteristics of Argentine students at middle school level, with or without a computer connected to Internet at home, and they conclude that availability of ICT at home not only increases the educational performancebut also decreases school failure. Lastly, Alderete and Formichella (2016) corroborate that there are significant statistical differences in the average educational performancederived from participation in the "Connecting Equality" Program in Argentina.

The second group of studies attests, essentially, that technological resources do not produce, in themselves, improvements in the school performance. In order for the introduction of new technologies to be successful in educational terms, additional actions and activities that generate a true innovation in the traditional teaching-learning practices and that ensure the appropriate, efficient and effective use of the new technological environment are required (Santin and Sicilia, 2014). This means that human and organizational capabilities are necessary to take appropriate advantage of the new technological resources potential. Along this line are Angrist and Lavy (2002), who assess a program to increase availability of computers in the schools in Israel. The authors conclude that the use of computer tools in the teaching-learning processes have significant and negative effects on the Mathematics outcomes for fourth grade students, while no significant effects are observed on the educational achievements of other competencies in higher grades. On the other hand, Fuchs and Woessman (2005) analyze the PISA 2000 outcomes for 31 countries and find that –once the student, family and school characteristics are controlled- access to computers at home affects the educational outcomes negatively while access to them at school is not related to such results. On the contrary, the authors evince the existence of a positive relationship between the use of computers at home and academic performanceof students, as well as a relationship in the form of an inverted-U with regard to their use at school – with academic results initially and, eventually, decreasing as the intensity of their use is increased.

On the other hand, Goolsbee and Guryan (2006) do not find changes in the school performanceafter assessing the application of the "E-Rateen" program that provides subsidies for the use of Internet at school in the United States. In a similar way, Leuven et at.(2007) do not find that the subsidy policy for computers and software in Dutch schools had a positive effect on the students' performance. WitteyRogge (2014) utilizes data of Holland, of the "Trends in International Mathematics and Science Study (TIMMS), and apply a pairing technique to build a control group and an experimental group utilizing the availability and intensity of use of IT as a treatment variable. The authors do not find significant differences in the outcomes of the test. Along the same lines, Barrera-Osorio and Linden (2009) assess the outcomes of the "Computers for Education" program in Colombia and conclude that the introduction of computers to educational centers does not have an effect on learning outcomes. Torres and Padilla (2015) also reject the hypothesis that ICT affects the academic achievement of Colombian students favorably. On

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the other hand, Severin et al. (2012) obtain a similar outcomewith the Peruvian program "A Laptop per child", contrary to what was found by Cristia et al. (2012). The authors suggest that the ICTs are a necessary condition but not enough to improve academic achievements; teachers need to have certain abilities to incorporate the new technological environment in their teaching practices (Córdoba and Herrera, 2013). In the same way, Muñoz and Ortega (2014) find that the programs that incorporate the use of ICT in teaching in Chile have not had any significant effects on the educational achievements. Lastly, it is worth highlighting the work of Sprietsma (2012) who, upon estimating the incidence in the access and use of computers and Internet on acquisition of competencies in schools in Brazil, he finds a negative impact on the results of Mathematics and Reading tests.

Starting with this revision of international literature, one can observe that this topic is still subject to discussion. In the case of Spain, there is no clear consensus on the causal effect of new technologies on educational performance. Cabras and Tena (2013) find a moderate evidence of the positive effect of the use of computers on students' performance, applying non-parametric Bayesian regression techniques to the data of PISA 2012. Such effect is significantly higher in the case of students that belong to less favorable socio-economic environments, which suggests that policy actions in the field can be a means to achieve greater equality. On the other hand, Calero and Escardibul (2007) and Cordero et al. (2012) utilize ICT variables as control variables of their respective studies on the determinants of Spanish educational performance through multilevel techniques. On the basis of data PISA 2003 Calero and Escadibul (2007) find that the student-computer ratio was not significant. With data of PISA 2009, Cordero et al. (2012) also find that such variable is not significant, whereas availability of computers at home affects educational performancepositively and significantly.

Escadibul and Mediavilla (2015) is the first study in Spain that finds differential effects on school performance based on the ICT variable. The results of the multilevel model with data of the PISA 2012 show that the global impact ofnew technologies is greater in the case of the Mathematical competence than in the reading competence (especially due to the positive effect of *access* to technological resources at home and at school). However, ICT use shows negative effects on students' performance(at home as well as at school in the case of the reading competence, and only at school in the case of Mathematics).

This research paper contributes to this debate about the potential differential effects of the variables associated with ICT on the educational performanceof Spanish students. Unlike Escadibul and Mediavilla (2015), this issue is studied through the Structural Equations Model (SEM), which provides greater flexibility than the regression analysis when assessing the causal relationships between access to ICT and academic performance.

Methodology, data and variables

Data Source and variables utilized

Empirical research utilizes the data for the Program for International Student Assessment (PISA, as its acronym in English) elaborated by the OCDE. Data for the PISA 2012 are utilized in particular. PISA is implemented every three years since the year 2000. Its objective is to assess to what extent 15-year-old students who are close to finishing their mandatory schooling cycle, have acquired the necessary competencies to develop their adult life and participate adequately in modern societies. Every year, PISA focuses on one learning competence: Mathematics, Language or Sciences; in the same way, each year it evaluates the two remaining competencies in a complementary manner (OCDE, 2013).

It is worth mentioning that, even though the standardized learning tests–as in the case of PISA- tests have imperfections and are criticized for them (Llach et al., 1999), in this moment there is no alternative statistical information source that could be utilized as *proxy* of the quality of educational outcomes.

The grading scale of the PISA tests varies from 0 to 100 and is elaborated in such a way that the average is 500 and the standard deviation 100. The assessment results are presented under the form of plausible values (PV) and constitute a representation of the capabilities of the student. Taking into account that the goal of PISA is to assess the dexterities of a population and not of each individual in particular, each student answers a certain number of items and it is estimated as if he or she had answered in all the cases. That is why, the PISA team elaborates five plausible values for each area using the information obtained, and

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explains that the correct method for estimatingany statistics consistently is to do it with each one of these five values separately and, then, to calculate their average (OCDE 2009).

In this paper, a model replicated for each competence studied at PISA is presented and, given that each competence has five plausible values associated with it, the model is estimated five times for each competence. Then, the model parameters are calculated in each area as an average of the results obtained.

Next, the variables provided by the PISA database that are later utilized in the proposed model are described;

- ICTHOME: Index indicating ICT availability at home.
- ICTSCH: Index indicating ICT availability at school.
- TCSHORT: Index representing scarcity of teachers. Higher values indicate greater degree of difficulty due to lack of qualified teachers.
- HEDRES: Index representing the amount of educational resources at home. It considers whether the student has a desk, a quiet place to study, a computer, educational software, books and a dictionary.
- SCMATUI:Index that represents the quality of the educational facilities.
- PARED: Continuous index that indicates the maximum number of years of education completed by both parents. It arises from considering the highest level between father and mother.
- NSP: Average School Socioeconomic Level. It is an average of the *ESCS* index of the school. The *ESCS* index summarizes information about the socioeconomic level of the student's home (parents' education, occupational status of the parents, material and cultural possessions in the home).
- ISI0Q03: Frequency with which student utilizes the WEB at school in order to study or do homework.
- IC10Q08: Frequency with which the student utilizes the computer at school in order to study or do homework.
- IC10Q01: Frequency with which the student utilizes the computer at school in order to study or do homework.
- IC09Q06: Frequency with which the student utilizes the computer at school in order to study or do homework.

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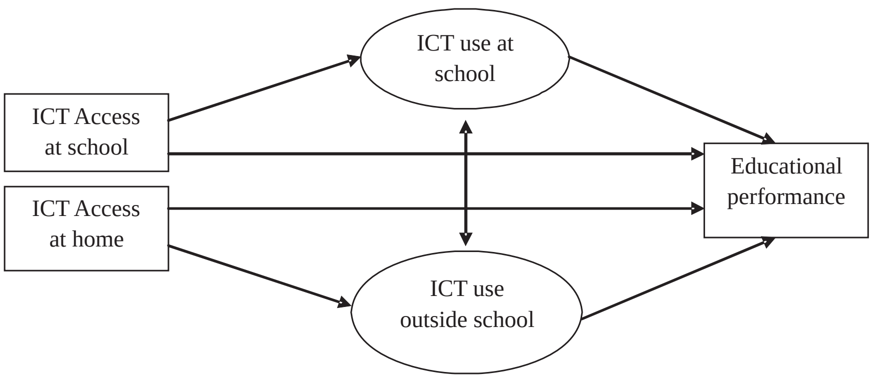
The variables observed in PISA that indicate frequency of use are of an ordinal kind and are composed of the answers in the following options: 1) Never or almost never' 2) One or two times per month; 3) One or two times per week; 4) Almost every day; 5) Every day.

Methodology

This research examines the causal relationship between access to ICT, use of ICT and educational performance, and it focuses on the mediating role of the use of ICT. The investigation question presents that access to ICT impacts educational performance mediated by the use of ICT. That is to say, access to ICT has a direct as well as an indirect effect on educational performance, mediated by the use. The conceptual framework is described in Graph 1.

FIGURE 1. Theoretical model



Source: Own elaboration.

In order to examine such relationships, a Structural Equations Model (SEM) is utilized. A structural model is defined as that in which parameters are not only of a descriptive nature, but also of a causal nature

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(Bollen, 1090). The presence of causal relationships between the variables that compose it is a fundamental element. In sum, the SEMs are a family of multivariate statistical models that enable us to estimate the effect and relationship among multiple variables. The salient aspects of these models are: the graphic representation of the causal relationships, presenting a hypothesis about the causal effects between the variables and the concatenation of effects among variables.

One of the main advantages of these models regarding the regression models is that they are provided with greater flexibility and are less restrictive since they include measuring errors in the criteria variables (dependent) as well as in the predicting variables (independent) (Ruiz et al., 2010).

That is why, their main usefulness is that they enable the presentation of the type and direction of relationships among variables in order to, at a later stage, estimate the parameters that are specified by means of the proposed relationships at a theoretical level. For this reason, they are also called confirming models given that the fundamental interest is "to confirm", through sample analysis, the proposed relationships on the basis of the theory utilized as reference (Ruiz et al, 2010).

In sum, the structural equations models must satisfy three conditions in order to define the causal relationship: isolation, association and causality direction. However, it is not easy to obtain each of these conditions, particularly the isolation condition that requires the causal relationships (cause-effect) not to be influenced by other factors. In the same way, it is worth noting that the existence of a causal relationship among variables must be sustained by the theoretical articulation of the model and not by its estimation with data of transversal kind (Ruiz et al., 2010).

On the other hand, it is worth mentioning that the SEM models often utilize two types of variables: observed and latent. The latent variables are not susceptible of being measured, by nature, and they do not have a precise definition either. Unlike the observed variables, which represent the observable characteristics of a phenomenon and can be measured directly, the latent variables may appear as lineal combinations of the observed variables.

Structural equations models generally are described through a trajectory diagram and an equations system. In the graphs, the observed variables are represented by rectangles while latent ones by means of ellipsis and circles. On the other hand, the equations systems have two important parts:

the measuring model and the structural model. The assessment of measuring models as well as the structural ones is necessary for the correct development of the technique (Barclay et al., 1995).

The measuring model defines the construction of each variable or latent construct through observable indicators and the mistakes that affect their measurements. On the other hand, the structuralrelationships model is the one they really wish to estimate and it is composed of the effects and relationships among the constructs, which shall normally be latent variables.

Structural equations models can be expressed in a general way through the following matrix equations:

$$\eta = B\eta + \tau\xi + \zeta \qquad (1)$$

Where X represents the vector of endogenous latent random variables of an mx1 dimension; ç represents the exogenous latent random variables of the nx1 dimension; B represents the coefficient matrix that govern the relationships between the exogenous variables and each of the endogenous ones, or in other words, the effects of ξ over η, its dimension is mxn and ξ represents the vector or perturbations or errors, of a mx1 kind.

In the same way, together with the structural model the measuring model is presented. The latter one is governed by two equations, one that measures the relationships between the endogenous latent variables and their observed variables:

$$\gamma = \Lambda_{\gamma}\eta + \varepsilon \qquad (2)$$

Where y is the vector of p observable variables (qx1);is the matrix of coefficients that show the relationships between latent and observed variables (pxm), which is also called load matrix; ε is the errors vector (px1).

The second equation of the measuring model is the one that governs the relationships between the exogenous latent variables and their observable variables:

$$x = \Lambda_{\gamma}\eta + \delta \qquad (3)$$

Where x is the vector of p observable variables (qx1); Λ_{x} is the coefficient or load matrix that show the relationships between the latent variables and the observed ones (qxm); δ is the errors vector (qx1).

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The model estimation is based on the maximum authenticity method thatimplies normalcy compliance. However, and advantage of the SEM models is that they are robust against non-compliance of this assumption (Schermelleh-Engel et al., 2003). A Stata 12 statistical package has been utilized for their estimation.

In this paper, the structural model is composed of three parts, three being the endogenous variables of the structural model: Use of ICT outside of school, Use of ICT at school and Educational Performance. Next, Table 1 indicates the variables that are included in the structural model to be estimated.

TABLE I. Description of the variables to be included in the model

Independent Variables (Exogenous)	**Dependent Variables (endogenous)**
Observed: ICT access at home (ICTHOME) ICT access at school (ICTSCH) Scarcity of teaching staff (TCSHORT) Amount of educational resources at home (HEDRES) Quality of school infrastructure (SCMATBUI) Parents educational level (PARED) Average socioeconomic level of the school (NSP)	Observed: Educational performance (PVMATH, PVREAD y PVSCIE) Latents: ICT use outside school (Use_outside) ICT use at school (Use_school)

Source: Own elaboration

The hypothesis to contrast the structural model posed are the following;

Use of ICT outside school

H1: access to ICT at home has a significant and positive effect on the use of ICT outside of school.

H2: use of ICT at school has a significant and positive effect on the use of ICT outside of school.

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Use of ICT at school

H3: access to ICT at school has a significant and positive effect on the use of ICT at school.

H4: use of ICT outside of school has a significant and positive effect on the use of ICT at school.

Educational Performance

H5: access to ICT at home has a significant and positive effect on educational performance.

H6: access to ICT at school has a significant and positive effect on educational performance.

H7: use of ICT outside of school has a significant and positive effect on educational performance.

H8: use of ICT at school has a significant and positive effect on educational performance.

H9: the educational level of students' parents has a significant and positive effect on educational performance.

H10: the amount of educational resources at home has a significant and positive effect on the educational performance.

H11: scarcity of teaching staff at school students attend has a significant and negative effect on the educational performance.

H12: the quality of school infrastructure students attend has a significant and positive effect on educational performance.

H13: the average socioeconomic level of the school students attend has a significant and positive effect on the educational performance.

Structural models usually described through a trajectory or path diagram. Thus, Graph 2 distinguishes the determinants of educational performance, and the relationships between educational performance, the use of ICT in and out of school, and access to ICT at both school and at home.

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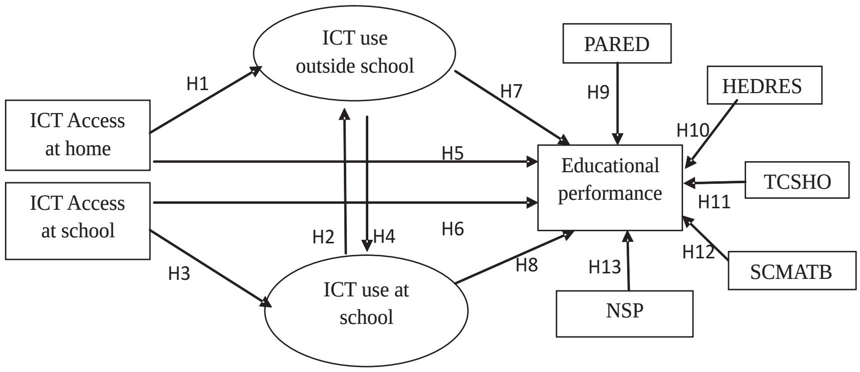
FIGURE 2. Determinants of the educational performance based on SEM



Source: Own elaboration.

According to Graph 2, the estimated model has two mediating endogenous latent variables: Use of ICT at school (called Use_school) and Use of ICTs outside school (called Use_outside). These variables are free of the effect of measurement error; such as it occurs with the common factor model of the factorial analysis. Therefore, in the first place, a measurement model is estimated for creating each latent construct starting from observable variables (exogenous) about activities and type of use.

The variables observed that compose the construct Use_school are: IC10Q03 (frequency of use of the WEB at school to do homework) and IC10Q08 (frequency of use of the computer at school to do homework). While those that form the construct Use_outside are: IC09Q01) frequency of use of the WEB outside of school to do homework) and IC09Q06 (frequency of computer use outside school to do homework).

In the second place, other determinants of educational performanceare included in the structural model, different from access and use of ICT. In the model presented, determinants of educational performance are supposed to be nine, of which two are latent variables that act as mediating variables: Use_outside and Use_school. Thus, the determinants that would have a direct as well as an indirect influence on educational performance, owing to being mediated by the use of ICT, are access to

ICT at school (ICTSCH) and at home (ICTHOME). In the same way, school level control variables are introduced – lack of teaching staff (TCSHORT)- as well as home level ones–educational level of parents (PARED) and availability of educational resources (HEDRES)-.

Results

Next, the results obtained on the basis of the hypothesis proposed are examined. We start by analyzing the construction of latent variables: Use of ICT at school and Use of ICT outside of school, defined as mediating variables.

The measuring model analyzes the individual reliability rating of the items that compose each construct. Table 2 and Graph 3 show the factors that construct the ICT Use at school and ICT Use outside of school variables in each on of the competencies analyzed by PISA. On Table 2 one can see that *z* tests for each one of the indicating variables present coefficients significantly different from zero. Therefore, these observed variables provide meaning to the construct designed based on the theory.

TABLE 2. Measurement models of ICT use at school and ICT use outside school

Latent constructs		**MATHS model**		**READING model**		**SCIENCE model**	
Variables	Factors	Coef.	p-value	Coef.	p-value	Coef.	p-value
Use_outside	Task using web outside	1	(constrained)	1	(constrained)	1	(constrained)
	Task using PC outside	1.576	0.000	1.5724	0.000	1.5942	0.000
Use_ school	Task using web at school	1	(constrained)	1	(c)	1	(c)
	Task using PC at school	0.7928	0.000	0.8019	0.000	0.8023	0.000

Fuente: Elaboración propia

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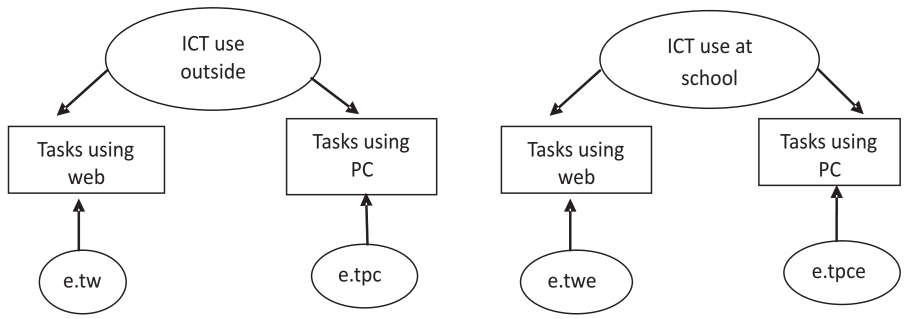
FIGURE 3. Measurement models of ICT use at school and ICT use outside school



Source: Own elaboration. Where e.t are the corresponding errors of each of the indicating variables.

In the SEM models the model adjustment assessment implies taking several measurements and criteria into consideration simultaneously, that is to say, there is no significant unique test to identify the correct model. Generally, the model adjustment criteria indicate to what extent the specified model adjusts to empirical data. Only one adjustment measure, the Chi Square,, has a significant test associated with it, while the rest of the measurements are descriptive. However, the problemof this test is that with increasing sizes of the sample and a constant number of degrees of freedom, the value of Chi Square increases. Therefore, a model based only on the significance of this test could be rejected even when the discrepancy between the sample and that covariance matrix implied in the model is irrelevant. Consequently, there cannot be paid too much attention to the significance of this statistic (Shemerlleh-Engely Moosbrugger, 2003).

In order to assess the global adjustment of the estimated model, the absolute measurements of adjustment on Table 3 are examined. There is a perfect adjustment when there is a perfect correspondence between the matrix reproduced by the model and the matrix of observations. The magnitude of the Chi Square statistic of the model proposed is high in the three competencies analyzed- Chi Square (28)= 1639.3 upon considering the performancein Mathematics, Chi Square (28) = 1931.9

upon studying the achievements in reading and Chi Square (28)= 1729.7 in sciences- and it presents a p-value of 0 in all the cases. Given that acceptable values of the statistic Chi Square close to zero are considered, the global model does not present, in principle, an appropriate goodness-of-fit adjustment However, as mentioned previously, it is feasible that in large samples, the statistic is not a good measure of goodness-of-fit adjustment, since the null hypothesis tends to be rejected. For that reason, given that the sample here utilized is large, other adjustment statistics re used.

In this sense, if the average quadratic approximation error is considered (RMSEA) or the root of the approximation quadratic error, it can be observed that the latter is lower than 0.10 in the three cases considered, which shows that the interval inferior limit of trust of 90% is lower than 0.05 and, therefore, the adjustment is good.

On the other hand the root median square residual (RMR) of JoreskogySorbom (1981) is a general measure of "maliciousness" of adjustment (as opposed to goodness-of-fit adjustment) that is based on the adjusted residues. Values closer to zero suggest a correct adjustment. However, this measurement is independent of the variables scale. In order to cope with this problem, a standardized root median residual is introduced (SRMR) (Bentler, 1995). Again, a zero value indicates a perfect adjustment. A rule that is usually accepted is that SRMR would have to be lower than 0.05 to affirm that a good adjustment is evinced.

TABLE 3. Goodness of fit of the model

Statistics	Value		
	MATHS	READING	SCIENCE
χ (28)	1639,3	1931,9	1729,7
$p > \chi$	0	0	0
RMSEA	0,056	0,056	0,056
SRMR	0,028	0,03	0,029

Source: Own elaboration.

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Once the goodness-of-fit adjustment of the model is verified, the structural model is analyzed. In the following tables (Tables 4 and 5) the results obtained upon estimating the model with performancedata in Mathematics, language and science are presented separately:

TABLE 4. Structural model. First part

Explanatory variables	ICT use outside school					
	MATHS		READING		SCIENCE	
	Coef.	p>z	Coef.	p>z	Coef.	p>z
ICTHOME	0,019	0	0.019	0	0.018	0
Use_school	0.399	0	0.402	0	0.399	0

Explanatory variables	ICT use at school					
	MATHS		READING		SCIENCE	
	Coef.	p>z	Coef.	p>z	Coef.	p>z
ICTSCH	0.301	0	0.299	0	0.299	0
Use_outside	0.185	0	0.187	0	0.185	0

Source: Own elaboration.

From the information of Table 4 it can be said that the use of ICT outside school is influenced significantly and positively by access to ICT at home (H1) as well as by the use of ICT at school (H2). In the same way, the use of ICT at school is affected positively by access to ICT at school (H3) as well as by the Use of ICT outside of it (H4).

In this way, it can be affirmed that –from the utilized sample data – hypotheses one to four presented previously are confirmed. This is verified by estimating the model for each of the competencies studied by PISA.

On the other hand, according to the data of Table 5, access to ICT at home and the use of ICT outside of school have a statistically significant and positive incidence on educational performance, taking into account the three competencies analyzed. This confirms hypotheses 5 and 7 presented in the previous section. These results corroborate the findings of various authors (Alderete and Formichella, 2016; Formichella et al., 2015; Mediavila and Escardibul, 2015; Botello and Rincon, 2014; Biagi and Loi, 2013; and Spieza, 2010) about the positive effect of access and use of ICT at home, contrary to Fuchs and Woessman (2005).

In the same way, access and use of ICT at school have a statistically significant incidence on educational achievements measured in Mathematics, language and science. However, contrary to what is proposed in hypotheses 6 and 8 the effect found is negative, and according to the coefficient values estimated, the influence of use is greater to that of access. It is worth highlighting that this result in relation to the use of ICT at school coincides with the findings of Escadibul and Mediavilla (2015), also for the Spanish case. In the same way, other authors have demonstrated the existence of a negative effect of ICT at school (Torres and Paidlla, 2015; Severin et al., 2012; Angrist and Levy, 2002). However, this result differs from Cristia et al. (2012), Aristizabal et al. (2009) and Machin et al. (2007) according to whomICT at school has a positive impact on educational achievements; and in some cases a greater effect than the use of ICT at home.

TABLA 5. Structural model. Second part

Explanatory variables	Dependent variables: educational performance at					
	MATHS		READING		SCIENCE	
	Coef.	p>z	Coef.	p>z	Coef.	p>z
Use_outside	8.1107278	0.001	8.8553852	0.0006	5.1890628	0.0336
Use_school	-9.924203	0	-11.395414	0	-10.530084	0
ICTHOME	4.0611904	0	2.9447634	0	3.0883598	0
ICTSCH	-2.5195672	0.0006	-4.6334244	0	-3.8530304	0
PARED	3.9601634	0	3.683286	0	3.8100302	0
HEDRES	11.551576	0	12.812082	0	11.022038	0
SCMATBUI	-1.1126997	0.0502	-0.67572642	0.2552	-0.88330246	0.1036
TCSHORT	-0.52599708	0.3536	-0.5175676	0.38	0.29892422	0.5952
NSP	35.034324	0	34.394104	0	28.75466	0

Source: Own elaboration

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According to Table 5, the control variables related to the home have been statistically significant – both parents' education as well as availability of educational resources-. Whereas, of the control variables related to school environment, the only significant one is the one that reflects the student body average socioeconomic level for the three competencies analyzed. The coefficients that accompany the three last variables mentioned have a positive sign, which coincides with the literature about the topic (Formichella and Kruger, 2013) and verifies hypotheses 9, 10 and 13 of the current paper.

Therefore, the factors that significantly and positively explain the educational performanceare access to ICT at home (H5), use of ICT outside of school (H7), the educational level of parents (H9), availability of educational resources (H10) an the student body average socioeconomic level (H13).

As it can be observed, the Use of ICT outside school (use_outside) is a mediating variable and reinforces the positive effect of access to ICT at home on educational performance. In other words, availability of ICT at home has a direct effect on the educational performance, and at the same time an indirect one, mediated by its use.

However, it is worth noting that the use of ICT at school has a positive effect on the use of ICT outside of school, which, at the same time, has a positive effect on the performance. Therefore, the use of ICT at school produces an indirect improvement in the educational achievements by means of using ICT outside the school (use_outside is also a mediating variable, in this case between the use_school and performance).

In the same way, the variable use_outside affects the use of ICT at school positively, which affects performancenegatively. In this case, the use of ICT outside the establishment has a direct positive effect on school results, but also has an enhancing role of the negative effect of the use of ICT at school, a practice that is observed as unfavorable at the time of achieving educational achievements.

Conclusions

This paper provides a contribution to the debate about the role of Information and Communcation Technologies (ICT) in education. Stemming from the PISA 2012 test for Spain, a Structural Equations Model

(SEM) has been estimated to measure the effect of access to as well as that of use of ICTon educational outcomes in mathematics, language and sciences. The mediating effect of the use of ICT at home and at school is examined in particular.

On the one hand, the hypothesis that posits that access to ICT at home improves school performancehas been verified. This can be explained by the ease that ICT provides when searching for information, solving problems or carrying out assignments using specific software programs.

In the same way, the fact that the positive effect of ICT availability at home was enhanced by the use of ICT outside of schools has been observed. That is to say, even though access has a direct effect, this can become more efficient if an adequate use of technology is carried out. Therefore, access to ICT at home also have an indirect effect, mediated by the use of ICT outside of the home. The more frequently students use a computer or Internet outside of school to do school homework, the greater the impact of access to ICT on educational performance. Posing ICT use as a mediating variable is a contribution of the paper that could explain the reasons why other authors have not found significant results on ICT on educational performance(WitteyRogge, 2014; Muñoz and Ortega, 2014; Barrera-Osorio an Linden, 2009, GoolsbeeyGuryan, 2006).

On the other hand, it was found that the goodness of ICT outside of school is not reproduced inside the school. This result that, at first, may seem contradictory with what was expressed previously can be explained in different ways. One of them is related to the idea of educability. Educability makes reference to the necessary social conditions so that an individual can go to school and successfully participate in class (Lopez, 2006). Such conditions refer to aspects of basic cognitive development, produced in the first years of life and it is associated, on the one hand, with affective stimulation, nourishment and sanitary conditions; and, on the other, with the primary socialization of children, which prepares them to insert themselves in an institution different from his family (Tedesco, 2000).

The traditional notion of educability refers to the fact that, according to the way school is organized, students "are expected" to have certain characteristics to be able to cope with it. However, students differ among themselves and not all have the necessary resources to articulate with what the educational system offers. In this sense, the introduction of ICT at school generates a new digital breach since it could represent a new

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barrier for those students who find themselves at a social and economic disadvantage upon entering the school system.

With this the intention is not to deter the use of technologies at school, but to emphasize how they are used and to what extent the different educability conditions of students upon entering the system are taken into consideration.

In the same way, beyond the question of differences of origin that there may exist among students, the issue of how technologies are used also represents a possible explanation for the results obtained. If schools have technologies, but their use in the classrooms is not appropriate inefficiencies may be generated. For instance, it may happen that the time that should be allotted to the teaching-learning process is allotted to the incorporation of ICT but that, by not making good use of them, this results in less time available for students to understand the syllabus content.

In this sense, the policy considerations that can be derived from this paper are related to the relevance of monitoring ICT use at school and with the need to diminish the digital breach of origin of students. The digital inclusion programs, such as the "School 2.0" implemented in Spain, in time it can constitute a useful tool to mitigate such breaches.

In the same way, the fact that students can make use of ICT outside school is presented as paramount. That is to say, it is required that they have the computer resources at home or that they have access to them and utilize them in some way. This consideration is in agreement with the policy programs that provide computers to students.

References

Acemoglu, D. y Autor, D.(2012). What Does Human Capital Do? A Review of Goldin and Katz's The Race between Education and Technology. *Journal of Economic Literature*, 50,2, 426-63.

Alderete, M.V. y Formichella, M.M. (2016). The effect of ICTs on academic achievement: the ConectarIgualdadprogramme in Argentina,*Cepal Review,* 119, 83-100.

Angrist, J. y Lavy, V. (2002).New evidence on classroom computers and pupil learning.*TheEconomicJournal*, 112, 735-65.

Aristizabal, G., Caicedo, M. y Escandón D. (2009). Las Tecnologías de la Información y Comunicación como determinante en el rendimiento académico escolar, Colombia 2006-2009. Disponibleen: http://2012.economicsofeducation.com

Banerjee, A.,Cole S., Duflo E., Linden L.(2007).Remedying education: Evidence from two randomized experiments in India, *Quarterly Journal of Economics*, 122, 1235-64.

Barclay, D., Higgins, R. and Thompson, R. (1995). The partial least squares approach to causal modeling: Personal computer adoption and use as an illustration. *TechnologyStudies*, 2(2), 285–309.

Barrera-Osorio, F. y Linden, L. (2009). The Use and Misuse of Computers in Education.Evidence from a Randomized Experiment in Colombia.*Policy Research Working Paper* Nº 4836, World Bank, Washington D.C.http://dx.doi.org/10.1596/1813-9450-4836

Bentler, P.M.(1995). *EQS Structural Equation Program Manual Encino*, C.A: Multivariate Software, Inc.

Biagi, F. y Loi M. (2013).Measuring ICT Use and Learning Outcomes: evidence from recent econometric studies. *European Journal of Education,* 48, 1, 28-42.

Bollen, K. A. (1989). *Structural Equations with Latent Variables.*New York, John Wiley& Sons.

Botello, A.L.H. y Rincón, G.A. (2014).La influencia de las TIC en el desempeño académico de los estudiantes en América Latina: Evidencia de la prueba PISA 2012. *Memorias Virtual Educa*, Memorias VE2014: Lima, Perú, 2014.

Cabras, S. y Tena, J. (2013). Estimación del efecto causal del uso de ordenadores en los resultados de los estudiantes en el test PISA 2012, en: INEE (ed.) *PISA 2012: Programa para la evaluación internacional de los alumnos. Informe español. Volumen II: Análisis secundario* (Madrid, INEE), 67-87.

Calero, J.y Escardíbul, J. O. (2007). Evaluación de servicios educativos: el rendimiento en los centros públicos y privados medido en PISA-2003, *Hacienda Pública Española*, 183, 33-66.

Carrillo, P., Onofa, M., y Ponce, J. (2010). Information Technology and StudentAchievement: Evidence from a Randomized Experiment in Ecuador. *IDB Working Paper* Nº 78.Disponibleen:http://www.iadb.org/res/publications/pubfiles/pubIDB-WP-223.pdf

Received: 21-07-2016 Accepted: 03-03-2017

Cordero, J., Manchón, C. ySimancas, R. (2012). Análisis de los condicionantes del rendimiento educativo de los alumnos españoles en PISA 2009 mediante técnicas multinivel.*Presupuesto y Gasto Público*, 67, 71-96.
Córdoba Gómez, F. y Herrera Mejía, H. (2013). Impacto del uso de objetos de aprendizaje en el desempeño en matemáticas de estudiantes de grado noveno. *Revista Virtual Universidad Católicadel Norte,* 39, 47-58.
Cristia, J., Ibarrarán, P., Cueto, S., Santiago, A. ySeverín, E. (2012).Technology and ChildDevelopment: Evidencefromthe One Laptop per Child Program. *IDB Working Paper* Nº 304.Disponibleen:http://www.iadb.org/en/research-and-data
Escardíbul, J.O. y Mediavilla, M. (2015). El efecto de las TIC en la adquisición de competencias. Un análisis por tipo de centro educativo (público/ privado). *XXIV Jornadas de la Asociación de Economía de la Educación*. Madrid, Junio 2015.
Formichella, M. y Krüger, N. (2013). El fracaso escolar en el nivel medio argentino: ¿es menos frecuente en las escuelas de gestión privada debido a su administración?.*Regional and SectoralEconomicStudies*, 13, 3, 127-44.
Formichella, M., Alderete, M. y Di Meglio, G. (2015). El acceso a las TIC en el hogar como determinante del rendimiento educativo en el nivel medio: un análisis para Argentina. Disponibleen: 2015.economicsof education.com/user/pdfsesiones/019.pdf
Formichella, M. M. (2010). Educación y Desarrollo: Análisis desde la perspectiva de la Equidad Educativa interna y del Mercado Laboral. *Tesis de Doctorado en Economía*. Universidad Nacional del Sur.
Fuchs, T. y Woessmann, L. (2005).Computers and Student Learning: Bivariate and Multivariate Evidence on the Availability and Use of Computers at Home and at School. *ifo Working Paper Nº8*. Munich: CESifo Group. Disponible en: http://www.cesifo-group.de/pls/guest/download/Ifo%20Working%20Papers%20(seit%202005)/IfoWorkingPaper-8.pdf
Goolsbee, A. yGuryan, J. (2006). The impact of internet subsidies in public schools.*TheReview of Economics and Statistics,* 88, 2, 336-47.
Hanushek, E. A. (1979). Conceptual and empirical issues in the estimation of educational production functions.*Journal of Human Resources*, 14, 351-88.

Received: 21-07-2016 Accepted: 03-03-2017

Jöreskog, K. G. (1973). *A general method for estimating a linear structural equation system*.In A. S.Goldberger and O. D. Duncan (Eds.), Structural Equation Models in the Social Sciences (pp. 85–112). New York: Academic Press.

Jöreskog, K. G. y Sörbom.D.(1989). *SPSS LISREL VII and PRELIS User's Guide and Reference*, 1st ed. Chicago: SPSS, Inc.

Levin, H. M. (1974). Measuring Efficiency in educational production.*Public Finance Quarterly*, 2, 3-24.

Leuven, E., M. Lindahl, H. Oosterbeeky D. Webbink (2007). The effect of extra funding for disadvantaged pupils on achievement.*The Review of Economics and Statistics*, 89, 4, 721-36.

Llach, J., Montoya, S. yRoldán, F. (1999). *Educación para todos*.Ed. IERAL.

Machin, S., Mcnally, S. y Silva, O. (2007). New technology in schools: is there a payoff?.*TheEconomic Journal*, 117, 1145-67.

Mediavilla, M. y Escardíbul, J.O. (2015). El efecto de las TIC en la adquisición de competencias. Un análisis de género y titularidad de centro en las evaluaciones por ordenador. PISA 2012.*Informe Español*: Madrid, España.

Muñoz, R. y Ortega, J. (2014). ¿Tiene la Banda Ancha y las TICs un Impacto Positivo sobre el Rendimiento Escolar? Evidencia para Chile.*El TrimestreEconómico,* 82, 325, 53-87.

OCDE (2009). *PISA Data Analysis Manual. SPSS.* (2da ed.). Ed. OECD Publishing. Paris.

OCDE (2013).*PISA 2012 Results: Ready to Learn: Students' Engagement, Drive and Self-Beliefs (Volume III)*.Paris: OECD Publishing.

Rodriguez, P., Nussbaum, M. y Dombrovskaia, L. (2013). ICT for education: a conceptual framework for the sustainable adoption of technology enhanced learning environments in schools. *Technology, Pedagogy and Education,* 21, 3, 291-315.

Ruiz, M.A., Pardo, A. y San Martín, R. (2010). Modelos de Ecuaciones Estructurales. *Papeles del Psicólogo*, 31,1, 34-45.

Santín, D., y Sicilia, G. (2014). *Evaluar para mejorar: Hacia el seguimiento y la evaluación sistemática de las políticas educativas. Reflexiones sobre el sistema educativo español*. Fundación Europea Sociedad y Educación, España.

Schermelleh-Engel, K., Moosbrugger, H. y Müller, H. (2003). Evaluating the fit of structural equation models: tests of significance and descriptive goodness of it measures. *Methods of PsychologicalResearch Online,* 8, 2, 23-74.

Received: 21-07-2016 Accepted: 03-03-2017

Severín, E., Santiago, A., Cristia, J., Ibarrarán, P. Thompson J. y Cueto S. (2011). Evaluación del programa "una laptop por niño" en Perú: resultados y perspectivas. *BID Educación* Nº 13. Banco Interamericano de Desarrollo.

Spieza, V. (2010). Does Computer Use Increase Educational Achievements? Student-level Evidence from PISA.*OECD Journal: Economic Studies*. Disponibleen:http://www1.oecd.org/eco/labour/49849896.pdf

Sprietsma, M. (2012). Computers as Pedagogical Tools in Brazil: A Pseudo-panel Analysis. *EducationEconomics,* 20, 1, 19–32.

Sunkel, G. y Trucco, D. (Eds.)(2012). Las tecnologías digitales frente a los desafíos de una Educación Inclusiva en América Latina - Algunos casos de buenas prácticas. Ed. Naciones Unidas: Santiago de Chile, Chile.

Tedesco, J. C. (2000) *Educar en la sociedad del conocimiento.* Ed. Fondo de cultura económica.

Torres Tovio, J. y Padilla Velásquez, A. (2015). Las Tecnologías de Información y Comunicación y su efecto en el rendimiento académico de los estudiantes en las escuelas Secundarias del departamento de Córdoba – Colombia. *RevistaElectrónicaIngeniería al día,*1,1, 15-23.

Witte, K. yRogge, N. (2014).Does ICT matter for effectiveness and efficiency in mathematics education?.*Computers & Education,* 75,173–84.

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