

# ***Is Having a Computer or Internet Available in the House Effective in Improving Performance in Mathematics or Spanish?***

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**Abstract:** Following the increased popularity of computers and internet among students, this paper studies the relationship between computer and internet usage at home on students' mathematics and Spanish test scores using the PROSPERA evaluation dataset. It also investigates how this effect varies across different income groups and over time. Overall, having computer and internet at home will have a positive and negative effect on test scores, respectively, and that having both computer together with internet at home will bring additional positive effects on students' test scores. In addition, these effects will converge towards zero over time, and the impact of internet and computer with internet is more significant for lower socio-economic groups, whereas that of computer is more significant for mid-income households. Our value-added regression shows that the impact of computer, internet, and computer with internet on test scores will all be insignificant except for the negative correlation between internet and Spanish test score. The students' family backgrounds and their study efforts appeared to be important determinants of test scores, with the father's education being a more important factor than that of the mother's for richer households, and vice versa.

**Keywords:** Computer at home, Internet at home, Primary education, Education outcome, Mexico

## **1. Introduction and Background**

In recent years, the emergence of the Internet has brought earth-shaking changes to people's lives. Among them, the impact of computers and the Internet on education is a prominent one. Their usage can be one of the major determinant for students' test scores, which, in turn, is closely related to their future [1]. This study will contribute to this topic by uncovering the potential impact of computer and Internet use on student performance through OLS regression models with controls, value-added models, and group regression, so as to form a reflection and improvement on students' education.

There is a large body of studies studying similar questions to ours, and the results were quite mixed. This work contributes to the debate by the following way: Firstly, more variables can be controlled thanks to the large and comprehensive PROSPERA evaluation dataset in Mexico explained later in

this section. Secondly, some literature, such as Perera and Aboal, tried to control for endogeneity bias by differencing the test score in the current period with that from the previous period [2]. However, this method assumes that the coefficient when regressing the current test score against the previous test score to be 1, while it is not safe to make this assumption because the two tests will not be perfectly identical in every aspect. This work relaxed this assumption by introducing a lag term, which involves including the test score from the previous year as a control.

The Conditional Cash Transfer (CCT) program provides funds to poor families in return for fulfilling specific behavioural conditions. It has effectively increased the literacy rate and graduation rate and reduced child labor incidents. The plan was first developed in Brazil and Mexico, and is now widely used in developing countries. The CCT program in Mexico was established in 1997, and is now called Prospera. The Prospera evaluation data set is widely used to evaluate the various impacts of the Prospera program on students.

The data used for this study is based on the Prospera evaluation dataset and the national standardized administrative test score data, as well as a survey of the parents, teachers and students. The standardized administrative test in Mexico is the national standardized annual test called Evaluación Nacional de Logro Académico (ENLACE) implemented by the Secretaría de Educación Pública (SEP) starting in 2006, which is applicable to both public and private schools. Our analysis will be performed using a longitudinal dataset for 4th graders in 2008.

## 2. Review of related literature

Biagi and Loi investigated the relationship between usage of Information and Communication Technology (ICT) on 2009 PISA test scores in mathematics, reading and science in various countries [3]. They obtained an index measuring the intensity of usage of technologies for several different groups of activities as well as its breadth (number of activities performed), and implemented their regression analysis country by country. The result revealed that all activities except gaming have a negative relationship on test scores in most of the countries, while the breadth of ICT use are positively and significantly associated with the PISA test scores in 21 of the 23 countries.

In addition to the impact of various ICT activities on learning, Wainer et. al. tested the relationship between access to computer and internet at home to the achievements on a standardized test for Brazilian primary school students [4]. Their result showed that for 5th graders in Brazil, there is a positive effect of around 20% of the standard deviation of owning computer at home, and this effect is moderately constant across different socio-economic groups (SEG). In contrast, the internet effect only appears to be significantly positive for higher SEGs, and is negative for households with lower incomes. Also, it was found that the effect size of computer/internet ownership have increased over time.

Young examined the possible effects of Internet use and social capital on students' academic performances using survey data collected from high school students in Seoul [5]. The survey was designed to include questions on Internet use time, pattern and frequencies of using mail or messenger. Results of the study demonstrated that Internet using time and entertainment-oriented usage were negatively correlated with academic performance. Surprisingly, learning oriented usage was not correlated with academic performance [5]. Despite these results, Young acknowledged that there was a positive relationship between mail or messenger use through the Internet and the social capital, which contributed positively to academic performance [5].

Jackson et al. was based on the HomeNetToo project. Participants of the project were limited to children came from relatively poor households and did not have access to internet at home [6]. In return for participating in the program, "the households received home computers, Internet access, and in-home technical support during the Internet recording period" [6]. Results of the study demonstrated that more Internet use was related with higher reading scores, and the relationship

between that and math score was insignificant. The authors attributed this to the fact that children read more when they are on the Internet, while browsing webpages do not typically engage math skills.

### 3. Data and Descriptive statistics

The Table 1 below shows the summary statistics of the variables of interest in this paper.

Table 1: Summary of Data

Year	Total Obs	computer	Internet	cell phone	Math Score	Spanish Score
2007	42008	15437	10561	27944	NA	NA
2008	42513	16030	11024	29385	514	507.25
2009	1854	799	593	1384	526.89	525.14

Therefore, a cross-sectional regression analysis will be carried out using the 2008 data due to its completeness. Also, the 2009 data will be used to build models with lag terms and to account for the time lag effect.

In the preliminary data analysis process, we deleted individuals without sufficient data only in key variables we would like to analyze to maintain the completeness of the data set and ensure that our data analysis results best reflect the original data.

In 2008, Computer availability remains between 1/3 and 1/2 while Internet availability remains between 1/4 and 1/3. Both fractions increased from 2008 to 2009. Moreover, as shown in the graph below, the relationship between Spanish Score and Math Score of 2008 has a positive correlation (0.8281) with an R-squared of 0.6718, indicating that Math and Spanish scores are highly correlated. In addition, the average scores in both Spanish and Math for individuals with access to Internet are higher than those of the individuals without access to Internet. Similarly, the average scores of individuals with computer access are higher than those of the individuals without computer access.

For both Spanish and Math, score of 2008 is a good predictor for the score of 2009. The Math score of 2009 and 2008 are positively correlated with a coefficient of 0.7167 and an R-Squared of 0.4864; the Spanish score of 2009 and 2009 are positively correlated with a coefficient of 0.6913 and an R-Squared of 0.4806. This indicates that 48.64% and 48.06% of variations in math and Spanish Scores in 2009 can be explained by the math and Spanish scores of 2008, respectively.

In 2008, the average scores in both Spanish and Math of individuals with access to Internet are higher than those of the individuals without access to Internet. Similarly, the average scores of individuals with computer access are higher than those of the individuals without computer access.

What individuals do with digital devices can be a crucial determinant for test scores. For example, due to differences in size and function of cell phone and computer, individuals may complete different tasks depending on whether they access Internet through computers or cell phones. Thus, we would like to explore whether Internet has different effects on test scores depending on the electronic devices the individual uses.

There were also differences in average Spanish and Math scores for 5 groups of individuals as shown in table 2: people with Internet and computer access respectively, people with both computer and Internet, people with Internet but without computer, and people without a computer but with cell phone and Internet.

Table 2: Interaction between computer, cellphone and internet

Computer only	Internet only	Computer & Internet	Computer but Intern	Cellphone & Internet but computer
534.2	525.8	537.1	532.7	463.8
531.3	523.3	535.2	527.6	455.1

*Note: Rows 1 and 2 report average mathematics and Spanish test scores for these groups respectively*

While individuals with both computer and Internet have the highest average scores in both subjects, individuals with only cell phones and Internet have average scores way below other groups. The result supports our previous hypothesis that the effects of Internet differ by the electronic device people use to access it. We will more closely examine this by adding in the linear regression model an interaction term of computer and Internet to test the effect of having computer with the internet. The interaction between internet and cellphone, however, is not included, as the most probable way for students to access internet without computers would be by using cell phone, causing collinearity issues.

Furthermore, we are also aware of the potential effects of the interaction between attending private school and the Internet. Given the possible differences in funding levels between private and public schools, private school students may have more Internet access at school and might also be better trained in using the Internet for academic purposes. The average scores of students with and without Internet in public and private schools are shown in table 3.

Table 3: Interaction between computer, cellphone and internet

Subject	Public	Public & Internet	Private	Private & Internet
Maths	419.9	388.8	515.4	530.3
Spanish	414.6	389.1	509.2	527.7

Indeed, among students who attend private school, the group with Internet access has higher average math and Spanish scores compared to the average level of test scores of private school students. However, among students who attend public school, the group with Internet access has lower test scores than those who do not on average. The difference provides an incentive for us to include an interaction term of public school and Internet in order to analyze the possible difference in the effect of Internet as classified by school type.

#### 4. Empirical strategy

We will run multiple different regressions to test the relationship between computer/internet usage and test scores. Firstly, we will regress the students' Spanish and Mathematics test scores in 2008 against the internet and computer dummies, while controlling for parental income, whether the household have cellphones and the type of language spoken at home. We included the cell phone dummy because it can reflect the awareness of the family of digital tools, which is related with whether the family has computer/internet. At the same time, it can also influence the students' test scores, causing endogeneity bias. The interaction between computer and internet will be included to not only understand the effect of having both computer and internet, but also to find the impact of having computers or internet only (that is, having computers without internet and having internet without computers). We suspect the impact of internet will also vary by whether a student attend a private or public school, so we added the interaction between the private or public school indicator and internet as well.

$$TestScore_{08} = \beta_0 + \beta_1 Comp_{08} + \beta_2 Internet_{08} + \beta_3 Computer * Internet + \beta_4 Internet * Private + \beta_5 Income + \beta_6 Language + \beta_7 Cellphone + \epsilon \quad (1)$$

After that, we added more control variables, such as class attention, class participation, hours study, skip school, number of siblings in their house, their home language and the education levels of their parents in 2008. Similar control variables were also present in Biagi and Loi's analysis [3]. In addition to this, whether the parents read stories to their children before they learned to read, whether the students' parents are at home and whether have electric power at home are added as controls as well, and the motivation for this will be explained in the next section.

$$\text{TestScore}_{08} = \beta_0 + \beta_1 \text{Comp}_{08} + \beta_2 \text{Internet}_{08} + \beta_3 \text{Computer} * \text{Internet} + \beta_4 \text{Internet} * \text{Private} + \beta_5 \text{Income} + \beta_6 \text{Language} + \beta_7 \text{Cellphone} + \beta_8 \text{Siblings}_{No} + \beta_9 \text{ParentsEdu} + \beta_{10} \text{Parents\_at\_home} + \beta_{11} \text{Gender} + \beta_{12} \text{Class\_attention} + \beta_{13} \text{Class\_participation} + \beta_{14} \text{Hours\_study} + \beta_{15} \text{Skip\_School} + \beta_{16} \text{ElectricPower} + \beta_{17} \text{Read} + \epsilon \quad (2)$$

In addition to the overall effect of technologies on student test scores, we are interested in how it affects students in various social-economic groups. Therefore, we employ a grouped regression model, which means to perform the regression analysis within each SEG. The group regression method solves the encoding issue of the family income variable as mentioned in section 3 as well.

The problem of unobserved variables and omitted variable bias, such as students' motivation and ability, still concerns us despite the rich set of controls included. We attempt to overcome this by using a value-added model which predicts the students' test score in 2009 using their test score in 2008. However, as the TestScore\_08 variable will naturally bring some controls, we will only control for variables that could change over time, which is family income in this case.

Finally, we will take into account of the fact that it takes some time for the students to familiarise themselves with computers and internet by regressing the test score in the year 2009 on computer and internet dummies in 2008.

## 5. Result and Discussions

### 5.1. Regression results on the whole dataset with less controls

We first ran multiple regressions with family income as a control variable, as it could potentially cause endogeneity bias. Explanatory variables include Internet, cellphone, computer, the interaction between computer and Internet as well as that between Internet and the private school indicator, and home language.

Interestingly, the correlation between Math Score and home language is also positively significant (59.390\*\*\*). This result may indicate that language skills like reading comprehension is also crucial for Math tests. One possible explanation is that understanding the given information and the proposed question is the first and an important step of successfully answering a Math problem. Indeed, Abedi and Lord found that students would prefer items that were simpler linguistically [7].

For both regressions, Internet is negatively significantly correlated with test scores. The interaction between Internet and computer has a positively significant correlation with test scores (Spanish: 31.715\*\*\*)(Math: 30.253\*\*\*). The interaction between Internet and private school has a positively significant correlation with test scores (Spanish: 86.395\*\*\*)(Math: 91.712\*\*\*). At the same time, computer alone is positively correlated with both test scores. Also, Internet alone may have a negative impact on students' academic performances, consistent with the result proposed by Young [5].

The positive coefficient of the interaction between internet and computer indicators might be because a student who accesses Internet through computer is more likely to be completing academic related tasks compared to a student accessing Internet in other ways, such as using cell phones. Moreover, the interaction term of Internet and private school has a positive coefficient, suggesting



that students in private schools may be better trained in using Internet for academic purposes due to more access to Internet at school.

## 5.2. Regression results on the whole dataset with more controls

We furthermore included some more family background and student engagement variables, and the coefficient of computer becomes much smaller (Spanish: 4.900) (Math: 4.070) potentially due to the less endogeneity bias. The interaction term of Internet and computer as well as that between Internet and private school indicator remained positively correlated with test scores.

Whether parents read for their children is positively correlated with test scores while the number of children within a family is negatively correlated with test scores. The indicator of whether parents read for their children reflects care received by children and to some extent shows how much attention parents pay on their children's education. These factors positively contribute to children's academic performances. By the same token, if a family has many children, the parents may pay less attention to each of them given the number of children that they need to take care of. Blake showed that the lack of parental interaction and attention to the children can lead to impaired verbal and cognitive abilities, which are major determinants to educational success [8].

Variables reflecting student's participation in activities and classes are all positively related to test scores. However, the coefficient for hours of study appears to be significantly negative. This might be due to demand characteristics of the participants and potential measurement errors.

## 5.3. Lag term regression

The two tables above illustrate regression results with lag terms (Spanish and Math score of 2008 respectively). We include family income of 2009 as our control variable. Variables like home language and parent's educational background should have little changes from 2008 to 2009, so we exclude them in our regressions. Test scores of 2008 is a good indicator of test scores of 2009 given the positively significant coefficients (Spanish: 0.656\*\*\*) (Math: 0.688\*\*\*) and high R-squared (Spanish: 0.485) (Math: 0.444).

Internet appears to have a negatively significant correlation (-66.447\*) with Spanish score, and it is not significantly correlated with Math score. One possible explanation for this result is that informal expressions online may negatively influence the student's usage of formal and correct Spanish, resulting in a lower Spanish score. Solving Math problems indeed involves correctly interpreting the questions, but such a process does not rely as heavily on the usage of formal Spanish and good grammar. The strong positive correlation between family income and test scores is also present here.

## 5.4. Regression by each SEG

The results of our grouped regression shows that the impact of computers, the Internet and computers together with Internet on test scores are quite different across socio-economic groups. For both subjects, the impact of internet and computer with internet are negative and positive respectively, but only for households with lower income. For families with higher socio-economic status, the effect of these factors were no longer significant due to a high standard deviation, which might be due to the fact that they use computers for a wider variety of activities. It is possible for children from richer households to use them for more purposes, as it is likely for students from better background to use the computers and the internet more frequently [9]. Interestingly, the effect of computers only is positive only for mid-income households, which might be due to the higher digital awareness of their parents. This reason may also explain the fact that the negative impact of the internet occurred only in lower-income families. Rideout and Katz supported this interpretation by finding that about a quarter of low and moderate income parents do not use computer at all [9].

Grouping regression based on family income gives us more information about the effects of other variables that could affect test scores as well. Spanish as a home language was positively affecting students test score in Spanish and Math, and the language advantage will decrease as family income goes up in both subjects. Also, we find that the school type effect is more significant for lower-income families. It may be concluded that students from lower-income families are mainly educated by schools rather than from their families, the society and so on. Similar reason can also be used to explain the positive coefficient of the interaction between computer and internet, as children from lower SEGs have fewer other sources of information and therefore emphasised computer with internet as a tool for information retrieval. The number of children negatively affected students' test score, and it is the case for all socio-economic groups. In fact, the negative impact will increase as family income increases. Blake reached similar conclusion that 'for those children whose parents are managing to furnish a reasonably adequate family life in other respects, the decline in sibling number will provide on average a distinct advantage...' and has provided an explanation that having more children could decrease marital stability, which affects childrearing [8].

We notice that in general, fathers' educational background is more significant than mothers' on test scores for richer households, while the mother's education were more important for poorer ones in terms of the coefficients. This could be because in poorer households, mothers are mainly responsible for taking care of children due to more severe gender discrimination [10]. In contrast, fathers in richer households tends to be more willing to help with raising children. Also, class participation and attention, as well as not missing school are essential determinants for test scores regardless of socioeconomic groups.

### 5.5. Taking into account the time lag effect

It is likely that the long run effect of computer/internet could be quite different from the short run effect, and similar hypothesis was also raised in Wainer et. al. that the society could learn the way to use computer and internet in children's education [4]. We tried to understand this effect by regressing the test scores in 2009 on whether the students have computers/internet at home in 2008, and contrast it to the regression result between computer/internet 2008 and test score 2008. The results are shown in figure 1.

The dot in the center shows the magnitude of the coefficients in our regressions, and the bars represents a 90% confidence interval. Our result shows that the effect of computers, internet and computers with internet tends to diminish over time, no matter whether the effect is positive or negative. The reduction in the adverse effect of internet can be explained by Wainer et. al.'s interpretation that the children, the teachers and the parents can be more experienced at moderating internet use [4]. The reduction in the positive effect of computer and computer with internet in the long run can be attributed to the fact that the children spends less time on academic related tasks once they are more familiarised with the entertainment features on the computer. Also, it is likely that the blue light produced by home computer usage before bed can affect melatonin production and sleep, thereby worsening test scores over time [11].

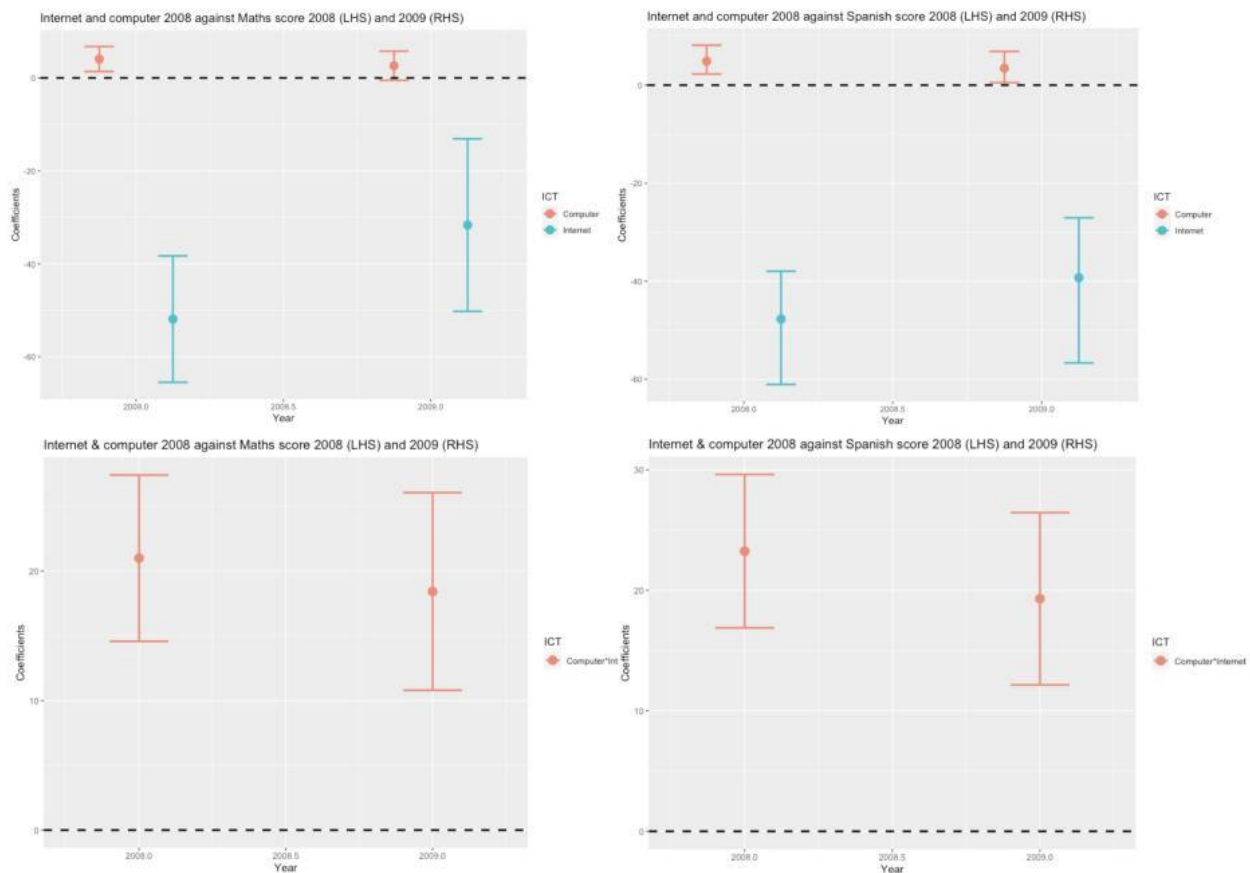


Figure 1: Coefficients of computer, internet, and computer with internet on Spanish and maths test scores

## 6. Conclusions

In conclusion, this paper discovered that overall, having computer and internet at home will have a positive and negative effect on test scores, respectively, and that having both computer and internet at home will bring additional positive impacts on students' test performance. These effects will all converge towards zero over time. Additionally, when controlling for the test score of the students in the previous year, the effects of these factors mentioned above are all insignificant, except for the significantly negative effect of internet on Spanish test scores. These results show that the expected positive impact of new technologies on learning outcomes cannot yet be confirmed and requires further investigation in the future. Furthermore, some other variables, such as family income, parents' education, whether the parents are at home, class participation and attention and not missing school are positively related to test scores, while the number of siblings are negatively correlated with test scores. Mother's education has less effect on test scores in richer families compared to father's education, and vice versa.

When performing our analysis by each socio-economic group, we found the impact of internet and computer together with internet on test scores to be negative and positive respectively on families with low income, whereas the positive effect of computers occurs only in mid-income households for both subjects. This observation can have significant policy implications, as the negative internet effect for poorer households and the positive computer effect for relatively richer households can be brought by the fact that they have different degree of digital awareness. Therefore, the government can establish education campaigns to increase it. Also, the government can create CCT programs that



subsidises the purchase of computers and the installation of internet at home to boost the school performance of students from disadvantaged family backgrounds. In addition, Marandino and Wunnava showed that the ‘One laptop per child’ program in Uruguay, which is similar to our proposed CCT policy, could also lead to an increase in parental income, especially for low-income households [12].

There are some improvement that can be done by future works based on our research. Firstly, the family income variable used in our analysis is categorical rather than numeric, and the data on some institutional factors, such as the technological infrastructure and ICT teacher training policies, are not present. Secondly, Punie et. al. mentioned that ICTs can still be foreign to traditional school curricula, meaning a more recent dataset with more variables can be used to analyse our research question [13]. Finally, our analysis is based on observational data, and some more experimental or quasi-experimental approaches can be adopted by future research in order to further control for endogeneity.

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