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Learn to Play & Play to Learn:
Evaluation of the One Laptop per Child Program in Costa Rica

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Abstract: The One Laptop Per Child (OLPC) initiative is one of the world's most popular interventions aiming to reduce the Information and Communication Technologies (ICTs) digital divide. Costa Rica introduced its first OLPC program in February 2012. In collaboration with the Quirós Tanzi Foundation (Foundation), implementing the program, baseline and post-intervention information was collected from a set of 15 primary schools that were selected to be treated, and from 19 primary schools that served as a comparison group. As this paper describes, using a difference in difference design, the short-term effects of the program on various outcomes of interest, namely: students' computer usage, time allocation, and test scores. The results indicate that the program led to an increase in treated students' computer use outside of school of about 5 hours per week. Moreover, the research provides evidence that the treated students used the computer specifically to browse the internet, do homework, read, and play. The research also demonstrates that the program led to a decline in the time that treated students spent on homework and outdoor activities. The research does not provide evidence to suggest that the program had an effect on participating students' school performance.

JEL Classification: I25, J24, O15

Keywords: Program Evaluation, Student Evaluation, Evaluation Methods, Economic Development, One Laptop per Child.[1]

Highlights

- Evaluated the short-term impacts of the One Laptop per Child Program.
- Students in the program used the laptop approximately 5 hours per week after class.
- Students most commonly used the laptops to browse the internet, do homework, and play.
- Students in the program spent one hour less per week doing homework and outdoor activities than nontreated students.
- There is no evidence that students shared the laptop with other family members.

[1]**Abbreviations:**
CCT Conditional Cash Transfers
ICT Information and communication technologies
ICT4D Information and communication technologies for development
OLPC One Laptop per Child
RCT Randomized Control Trial

1 Introduction

As stated by the World Bank Group (2012): "Information and communication technologies have great promise to reduce poverty, increase productivity, boost economic growth, and improve accountability and governance." At the same time, United Nations Sustainable Development Goal 9.c, urges countries to increase citizens' access to information and communications technology to promote inclusive economic prosperity (United Nations General Assembly, 2015). In an effort to increase the number of students who from an early age receive instruction in technological skills, NGOs and Governments have been implementing projects to equip classrooms with computers. In recent years, different programs that aim to modernize school inputs have been introduced all over the world, providing more school age children with access to computers. However, implementers often encounter challenges to provide computers to schools because the initiatives often are very expensive and do not include tested and well established methods to train students to use computers in ways that do not compromise students' learning processes. Moreover, implementers have been limited in their abilities to present well-informed recommendations to implement, improve, and expand these initiatives by a general lack of empirical evidence quantifying the overall impacts of these programs and their effects on students' cognitive and non-cognitive skills, short- and long-run outcomes, and externalities. Consequently, these initiatives must be rigorously evaluated.

One very renowned and widely implemented program is the One Laptop per Child (OLPC) program. The MIT Media Lab conceived and created this revolutionary project to provide students in elementary schools with low cost and durable laptop computers. Each student who participates in an OLPC program is given a laptop computer, which he or she must carry into the classroom every school day. In some countries students are allowed to take the laptop home throughout the school year. The main objective of this initiative is to provide underprivileged children with access to computers, and to close the digital divide that exists between people of different socioeconomic status and countries. This initiative is strongly linked to what is known as 21st Century Skills, which posits that society and human capital require new skills that are not well incorporated into the current education systems. The OLPC program also belongs to the group of initiatives known as Information and Communication Technologies for Development (ICT4D), which argues that improving people's access to more and better information will further the socio-economic development of society.

The mission of the OLPC program is to "provide means for learning, self-expression, and exploration." With this mission, this initiative goes beyond the traditional target of improving students' academic performance; the mission aims also to develop resource-educated, well-informed, interconnected, and empowered children.[2] OLPC programs have expanded rapidly across the globe; as of today, OLPC programs have distributed 2.4 million computers to students in 44 different countries, mostly of which are less developed countries.[3] Latin American countries that have implemented the program include Brazil, Peru, Colombia, Uruguay, Haiti, Paraguay, Nicaragua, and recently Costa Rica (Nugroho and Londsale 2009).

Most policymakers agree that this intervention is relevant and acknowledge that it revolutionizes conventional teaching techniques and tools by supplanting teachers and textbooks as the only sources of information. The intervention aims to empower students and provide them with the capacity to find knowledge by themselves. Governments generally support these initiatives because they currently face strong pressures to adopt more modern educational systems, and, in many cases, advocate for the universal distribution of laptops or tablets in their public school systems.

Despite the recent popularity of OLPC programs, critics of this and similar initiatives argue that the program is expensive, disrupts the educational process, imposes additional burdens on the teachers, and that students mostly use the computers to play games. Moreover, typically, the programs are abandoned after the initial computers start to break down.[4] In order to reconcile opposing opinions and ensure that computer assisted programs are optimally designed, it is essential to develop evidence-based research and recommendations.

All OLPC programs provide school age children with access to laptop computers; however, not all of these programs are implemented in the same ways. Some interventions assign a computer to each student, while others assign more than one student to each computer. Certain interventions also provide school infrastructure, including internet connectivity, while others do not. In some countries the laptop is used only for specific courses or topics, while in other countries the laptops are used in programs or run software programs that are not tailored to any course in the standard

[2] http://laptop.org/en/vision/mission/
[3] A complete and updated list can be accessed at http://one.laptop.org/map
[4] See: http://wiki.laptop.org/go/Concerns_and_criticism

curriculum. After considering these differences, it is important to note that different implementation methods and activities are expected to lead to different outcomes.

To this day, most of the existing literature on computer adoption in education has analyzed the effects of the tool on students' school performance, and has found little or no evidence of positive outcomes. The question remains unanswered as to why students' use of computers does not seem to improve their school performance. To answer this question, research must conceptualize the causal pathways through which the OLPC program generates effects on beneficiaries on the short-run, mid-run, and long-run. This research paper aims to assess the resources that are available and are being utilized in the intervention, the activities that take place throughout the implementation of program, and answer what are the short term effects of the program on computer usage as well as intermediate inputs such as personal time allocation rearrangement, and, finally, on school performance outcomes.

This paper describes the impact evaluation of the first year of the OLPC program in Costa Rica. In early 2011, the Quirós Tanzi Foundation (Foundation), responsible for funding and implementing the program, selected a treatment group of 15 primary schools in 4 different districts, to receive laptops during the first week of classes of 2012.[5] The Foundation chose these treatment districts and schools not randomly. After the treatment group was determined, a control group of 19 primary schools located in the same four districts were selected before the program was publicly announced. Through planning and collaboration with the implementing organization, baseline and endline data was collected through household surveys, enabling to answer the research questions utilizing a difference in difference estimation.

This impact evaluation analyzed two alternative hypotheses as to why the OLPC programs had not led to any changes in students' school performance in the short-run. The first hypothesis is that students were not using the laptop computers significantly inside or outside class and that, therefore, we shouldn't expect any outcomes from this intervention. The second hypothesis is that students were significantly using the laptops; however, they were developing skills through the program that were orthogonal to the topics that the traditional school curriculum tested. In other

[5]The school year in Costa Rica goes from February to November.

words, although the program generated technological skills, these skills did not significantly affect or improve students' academic performance.

This paper first examines computer usage. The analysis aimed to determine the intensity of students' use of the laptop inside and outside of the household. After usage was assessed, the study explored the students' specific use of the computers: e.g., whether they used computers for educational purposes (such as doing homework or finding information online) or for leisure (such as drawing or playing computer games). Secondly, this research sought to determine how having a computer affected intra-household relationships and time allocations within the household. To assess these effects, the study determined the amount of time that the student spent doing homework, household duties, and outdoor activities. Further, it was analyzed the time that the parents devoted to helping the student with homework, and if the parents or other family members shared the computer with the student. Finally, the research examined the intervention's effects on the students' school performance by applying two different tests: a math and a cognition test. The math test was selected because the software loaded on the OLPC computers contained applications designed to assist with math problems. The cognition test was selected because other applications installed on the OLPC computers were designed to improve the creativity and non-verbal abstract reasoning of the students.

The findings indicate that the program led to a significant increase in students' computer usage: treated students used a computer almost five hours more per week than their non-treated counterparts. The results also show that the treated students used the equipment to run various applications, such as to browse the Internet, read, and play computer games. The evidence also indicates that the students who received the intervention spent about one hour less of their time per week doing homework and performing outdoor activities than non-treated counterparts. The evidence did not suggest that the students were sharing the computer with other family members. Consistent with the existing literature, the evidence did not show that the intervention had significant effects on improving students' test scores.

In addition to describing the empirical evidence of the short-term effects of the OLPC program in Costa Rica, this paper also aims to contribute to the literature concerning schools' adoption of computers by "taking a step back" and focusing on the intermediate effects of providing students with a laptop computer to be utilized in class and at home. To understand better whether and how

students used the laptop computers, this research collected and utilized primary data to estimate the short-term effects of the OLPC program, particularly computer usage intensity, specific uses, and changes in time allocation, which would affect intermediary inputs, such as the time students spend doing homework or self-learning. Finally, this paper presents the analysis of the intervention's impact on school performance by estimating effects on students' test scores.

The paper consists of the following sections: Section 2 presents the literature review on school inputs and on OLPC programs. Section 3 describes the program. Section 4 explains the stages of data recollection. Section 5 presents the study's empirical strategy, and Section 6 describes the study's results. Finally, Section 7 presents the conclusion and describes future research plans.

2 Literature Review

The existing literature about the integration of computers into standard education is evolving. Authors describe mixed outcomes and research has focused mostly on the effects of these programs on school performance. Angrist and Lavy (2002) studied a program in Israel that distributed 35,000 computers to schools; they found that the computers had no effects on students' performance as measured through test scores. Banerjee et al. (2007) studied the impact of a program dedicated to increase computer use, which was adapted with math specific software for students in India. In this program, the treatment group had access to two hours per week of shared computer time in which students played computer games to reinforce mathematics skills. The authors used a randomized experiment design and found positive and significant effects on participants' math test scores during the period of the intervention, but no effects on their test scores in other subjects.

Barrera-Osorio and Linden (2009) evaluated the effects of a program that donated computers to public schools selected through random assignment in Colombia. The authors found no effects on participants' test scores. In their paper, they argued that this outcome resulted from the fact that the computer use was not effectively incorporated into the educational curriculum. Carrillo et al. (2011) also utilized random assignment to evaluate a computer aid instruction program for math and reading classes in Ecuador. The authors found positive effects on students' math test scores, but no effects on their language scores. The results from these studies suggest that guided use of

computers through their incorporation into the educational process is necessary to improve students' test scores.

Fairlie et al. (2010) studied the causal relationship between owning a computer and educational outcomes in high school in the United States. They found that students who have computers are more likely to graduate, and argued that computers make it easier for students to complete school assessments. However, in a more recent study, Fairlie and Robinson (2013) evaluated the impacts from a large experiment in which computers were randomly provided to students for home use. This study found significant increases in students' computer usage, but no effects on students' educational outcomes and on the amount of time that they allocate to do homework.

Not all studies show positive effects from computer adoption on school performance. Vigdor and Ladd (2010) studied the effects of introducing home computers in part of the United States. Utilizing variation in students' access to a home computer and the timing of the introduction of high-speed internet into given areas, their study found that access to a home computer led to negative impacts on students' math and reading test scores. Malamud & Pop-Eleches (2011) found similar results in their evaluation of a program in Romania that provided vouchers to low-income families to facilitate the purchase of home computers. Contrary to what they originally had expected, the authors found that the students from families that bought computers performed worse in school than those without computers. The authors explained that the outcome resulted from the fact that the students with home computers spent more time playing video games and less time doing homework and studying than those without home computers.

The literature on OLPC programs is still novel and fairly limited, and focuses primarily on the effects of the laptops on students' performance. In the largest scale OLPC study to date, Cristia el al (2012) evaluated the OLPC program in rural schools of Peru using a randomized experiment. The authors found no significant effects on students' math and language test scores. They, however, found that computers positively affected students' results on a progressive matrices cognition test and on a coding test. The authors explained that these outcomes resulted from the lack of teacher training, education resources, and connectivity, which impeded the program's ability to achieve its potential for school performance. In another study regarding the same OLPC program in Peru, Beuermann et al. (2012) focused on the program's effects on the students who were able to take their computer home after class. Through the use of a randomized experiment,

they found that the students who used the computers at home were more likely to perform home duties but less likely to spend time reading books. The authors found no effects on student technological skills by testing use of a Windows based PC and an Internet browser. De Melo et al. (2014) evaluated the impact of the OLPC program in Uruguay. The authors found no effects on students' math and reading test scores and presented evidence that the students used the laptops mostly to browse the internet. The authors argue that the fact that students used the computers for browsing explains why effects shouldn't be expected in their test scores.

Sharma (2012) found no effects on students' test scores when he analyzed the OLPC program in Nepal. The author concluded that, even though his study failed to find positive effects on students' school performance, had he utilized a different evaluation design that included variables concerning family members' computer usage, he might have found positive effects of the program. Mo et al. (2013) conducted a randomized control trial for an OLPC program involving students from 13 migrant schools in China. Each participant in the treatment group received a laptop computer and participated in a session about how to use the computer. On each of these computers the program had installed tutoring software for students to use at home, which was tailored to match the school's curricula. The authors found that the program improved students' computer skills, which they tested by administering eight questions about basic computer usage. The findings also show an increase in students' math performance, but no spillover effects on reading ability. Lai et al. (2015) also conducted a randomized control trial for a computer assisted learning program in 43 migrant schools in China. In this case the program provided remedial computer assisted math learning to students outside of regular school hours. The authors found an increase in students' math test scores and an improved interest in learning, yet no spillover effects on their language test scores.

As described above, the existing literature consistently shows that providing computers to students only seems to improve their school performance if students receive guidance on how to use the computers for a particular course. If the students do not use the computers to complement their existing school curriculum, the students' use of computers does not seem to generate any positive effects on their school performance, and may even lead to negative effects. This paper contributes to the existing studies of computer adoption in schools and OLPC by reporting on our assessment

of how students use laptop computers with connectivity, the intensity of and extent of their use, and how students reallocate their time when they possess a computer.

3 The Conectándonos Program

In 2010, the Quirós Tanzi Foundation decided to implement an OLPC program in a set of public elementary schools[6] in Costa Rica. The Foundation provided a laptop computer known as XO, which costs approximately $209 per unit. This computer was designed in 2005 and operates using free software. Since its early stages of construction, the XO was oriented toward children; it has a waterproof and shockproof design. At the same time, the XO has all of the standard features of any other laptop computer, such as wireless connectivity, USB ports, speakers, microphone, camera, and headphone jack. Figure 1 in the Appendix depicts the XO laptop.

In the first year of the program (2012), the Foundation distributed 1,550 laptops within 15 public primary schools in 4 districts of Costa Rica that it chose in collaboration with the Ministry of Education. In the second year of the program, the Foundation provided another 1,500 laptops to the remaining eligible schools in these 4 districts. To this day, the Foundation has distributed almost 5,000 additional laptops to 74 schools across the country and mostly in rural areas. The program has a one-to-one scheme: each student is given a computer that is used about one hour per day during class and that the student can take home after school. A difference between this program and other OLPC programs is that the Conectándonos Program provides the computers, and, also, because it is a quality-oriented program, carefully trains and guides teachers and repairs broken laptops within two weeks. The Foundation trains the teachers before the start of every school year, and a multidisciplinary team composed of educators, technicians, and coordinators visits every school weekly to guarantee that there are no problems with the teaching techniques or with the equipment. The Foundation collects the computers for maintenance in December every year and returns them to the participating students the following February.

This program has five primary costs: the XO laptop, school infrastructure fixed costs, internet/electricity bills, teacher training, and the cost of the weekly follow-ups by the

[6] Public schools in Costa Rica charge no tuition or any other fees.

multidisciplinary team. According to the Foundation, the initial fixed costs amount to approximately $225 per student and include the costs of providing a laptop for each student and teacher, required infrastructure, and teacher trainings. In addition, the annual variable costs amount to approximately $225 per student and include internet services, electricity, technical support, and pedagogic follow-up visits. According to the Foundation, the majority of these variable costs come from fixing and replacing broken equipment: 40 percent of the equipment needs at least one repair per year. The most common fixes are replacing the keyboard, screen, and the battery charger.

The Foundation's school selection process was the central component that influenced the data collection and empirical strategies used to conduct the impact evaluation. The Foundation selected the treatment schools one year before the start of the program. In a first stage, the Costa Rican Ministry of Education gave the Foundation a list of all of the public elementary schools in the country. The Foundation decided that the schools that had computer laboratories already were ineligible for the program. As a second step, the Foundation decided that very small schools (schools that had only one teacher) and very big schools (schools that enrolled more than 500 students) would not be considered for the program. Finally, with the weekly follow-up visit plan in mind, the Foundation decided to exclude from the program schools located more than a three-hour drive away from the San José metropolitan area. After the Foundation applied these filters, it selected the four districts that had more than three eligible schools. From these four districts, in collaboration with the Ministry of Education, the Foundation selected the schools to be treated in Year 1, and determined that the remaining schools would be incorporated into the program in Year 2. The schools the Foundation chose to begin in Year 2 constitute the control group in this evaluation.

The first selected district was Río Cuarto, which had ten eligible schools and two ineligible schools. The Foundation selected four schools to be a part of the program in Year 1 and identified six to be incorporated in Year 2. The second selected district was San Isidro, which had five eligible schools and three ineligible schools. The Foundation selected the five schools to be a part of the program in Year 1. The third district was Santa Teresita, which had six eligible schools and two ineligible schools; the Foundation selected three schools for Year 1 of the program, and the remaining three were incorporated in Year 2. The fourth district was Curridabat, with four eligible schools and two ineligible schools. The Foundation selected three schools for Year 1 of the

program and the remaining school was incorporated in Year 2.[7] The first three districts mentioned are located in rural areas in which the main economic activity is agriculture. The final district is located in an urban area close to the capital city. Figure 2 shows a map of the four districts in which the program began.

4 Data

The data used in this paper come from two household surveys that were conducted on the students and parents of a treatment group and a control group. The baseline survey was conducted between November 2011 and February 2012. As described in the previous section, the treatment group consisted of 15 schools located in 4 districts. The control group consisted of the 10 schools (from the same 4 districts) that the Foundation chose to incorporate into the program in the second year. From here on, this group will be referred as Control 10.

An unexpected occurrence that arose was that the treatment group for this evaluation came to be twice as large as Control 10. To address this issue, the remaining nine untreated schools within the four districts were also selected. This provided an expanded control group of 19 schools (referred to as Control 19). In summary, this impact evaluation studied 15 treatment schools and 19 control schools, which educate approximately 3,300 students, the population of all of the public elementary schools within the 4 treated districts. Table 1 details the location and characteristics of the treatment and control schools.

The household survey consisted of two independent components: a survey of the students and a survey of the parents. For the first round of surveys, to guarantee that the students understood how to accurately answer the questions, the students completed the survey questionnaire in class with the teacher's instruction and assistance. The parents received their questionnaire at the same time that they received a contract that they had to sign to accept the laptop; the parents received these documents one week before the laptop was distributed. To receive the laptop on the first day of

[7]Please note that due to the fact that the NGO prioritized the success of the follow-up visit scheme over the evaluation design, it was not possible to randomize the selection of the treatment schools during Year 1 of the program. The first group of treatment schools was chosen by the NGO in order to facilitate their weekly logistics.

classes, the students' parents had to have completed both the questionnaire and contract. This design enabled us to receive near perfect response rates to its survey of the treatment group.

To avoid contamination of information, the Foundation delivered and collected questionnaires to the control group during the last week of classes of the previous school period.[8] The student survey to the control group identically as to the treatment group. However, because this group was not to receiving computers, the parent survey was sent to the household as homework. The schoolteachers collected the returned surveys the next day. For the control group there was a non-response rate of around 20 percent. To address the issue of response bias, an attrition analysis was performed, which is described in the last section of the results.

The second round of surveys in February 2013. Because the Foundation collected the laptops at the end of the 2012 school year and returned them to the students with a new contract in the beginning of the 2013 school year, the method of attaching the survey to the contracts was repeated. A near perfect response rate was obtained from both the original treatment group and from the Control 10 schools that became part of the treatment group in the second year of the intervention. For the remaining nine schools in the control group, with the assistance of the principals and schoolteachers, surveys were sent to the households as homework.

Two clarifications regarding the second round of surveys are necessary. First, 6th graders were interviewed at the end of the 2012 school year because they were entering high school in 2013, the next year. Second, some students transferred schools during the intervention, thus missing students were searched for in all of the schools within the same district. If these students were found, the second observation was included as if they had remained in the original school, where treatment (or not treatment) happened. A timeline of the data collection is provided in Figure 3 of the appendix.

The parental questionnaire contained a very broad set of topics. The first subsection gathered socio-demographic information from the household to help identify the family in the future, and also to collect variables that will be used as pre-program controls. These variables include individual's name, ID, and phone number, age, gender, size of the household, number of children

[8]Some control schools are located very close to treatment schools, thus, students enrolled in the former schools likely would know about an OLPC program in their district, which could possibly affect their responses.

in the household, family income, expenses on the children, gender of the head of the household, education completion, and presence of a computer and internet at home. The second part of the questionnaire contained questions about aspirations, such as the parents' educational objective and desired profession for the student, and their preference for the child to continue living in the same town in adulthood.

The next section of the questionnaire concerned behavioral characteristics such as the amount of time that the parents spend helping the children with their homework, time that the student spends doing homework, home duties, and outdoor activities. Finally, the survey asked questions about computer use at home, including amount of weekly computer use by the child and other family members, functions for which the computer is believed to be useful, and if the parents prefer the children to use a computer more or less. Table 2 presents the baseline summary statistics from the information provided by the parents.

The student questionnaire gathered the following information: the type of occupation that the student desired in adulthood, the favorite class, school satisfaction, hours of computer usage, uses given to the computer, and with whom the computer is used. Table 3 provides the baseline summary statistics from the information provided by the students. Column 1 includes all of the schools; column 2 includes the treatment schools; column 3 includes the Control 10 schools; and column 4 includes the Control 19 schools. T-tests are reported in columns 7 and 8.

Households in the studied districts on average have 5 members, 2 of whom are children under age 12. The monthly income of the household is approximately $500. Out of that total income, about 10 percent is directed towards the schooling expenses of the student and about 18 percent to the expenses for the other children. Most parents completed primary education. Only about 30 percent of the households have a computer at home and 20 percent have internet connectivity, as shown in Figure 4. On average, parents help students with homework about five hours per week. Only half of the students claim to have ever used a computer, but 70 percent of the households report having at least one family member who has ever used one. The students' most desired professions are medical doctor, engineer, and teacher. All of the students' occupational responses are shown in Figure 6. The students on average spent a little more than six hours per week performing outdoor activities, and a similar amount of time doing homework. The students also claim that they used a computer around two hours per week at home, and spent one hour outside; while the other

household members reported using a computer approximately four hours per week. Finally, 90 percent of the parents reported that they desired that their children would spend more time using a computer.

The last section of the data collection consisted of test scores that were obtained from students in a subsample of treatment and control schools. As mentioned in the previous section, this paper aims to take a step back from previous analyses on the effects of computers in schools. To do so, this research, mainly focused on the short-term analysis derived from computer usage instead of the effects on students' school performance. However, to strengthen our evaluation of the overall short-term effects of the program, test scores for the upper level students were also included. Due to the lack of consolidated and comparable school records across treatment and control schools, and the resource limitation that made it unfeasible to conduct tests on the schools before the computers were being distributed, it was not possible to gather baseline performance data. Therefore, only post-intervention data was collected in order to perform a single difference approach[9].

To address the issue of selection bias, a two-step approach was followed to select the schools to be tested. First, based on observable characteristics, it was determined that Control 10 was the most adequate comparison subgroup, thus it was chosen as the subgroup to be tested. Second, for each Control 10 school, the treatment school from the same district that was most comparable after matching observable characteristics was also chosen to be tested. This approach allowed the identification of the most comparable subsample of 10 treatment schools and 10 control schools.

Math and a Cognition tests were applied to students during the months of March and April 2013. The Math Test was an adaptation taken from the World Bank Math and Reading Student learning achievement documentation, and specifically the instrument developed for the Mongolian education system fifth graders as a part of the READ Project. The cognition test was a progressive matrices test designed for sixth graders, which previous research considered a good indicator of the effects of computer use on general intelligence (Malamud and Pop-Eleches, 2011). This test adapted the Wechsler Scale (WISC-R III) designed for kids under age 15. It consists of a set of progressive matrices, which are incomplete and intended to measure the cognitive ability of the

[9] Since treatment was not randomized, the single difference estimator is going to contain selection bias.

sampled students. The specific topics evaluated were attention, observation, detail perception, concentration, and order.

Additional data sources that were explored included students' school records, and aggregated information on test scores. However, due to the lack of standardized tests across schools in Costa Rica, and the lack of consistent and homogeneous school records, if any, it was decided not to include this information as it would not accurately represent the schools' performance. Finally, in situ information was gathered and verified regarding: number of students, teachers and classrooms, and whether the schools had electricity, a library, and a computer laboratory.

5 Empirical Strategy

To assess the impact of this program, one needs to calculate the difference in the outcomes of the treated students as compared to their potential outcome having not been treated. However, since a student cannot be selected to participate and not selected to participate at the same time, we have the usual missing information problem. For this reason, a control group of participants who resemble the treated students and who live in the same district, but that were not selected to participate in the program during its first year of implementation was chosen. Given that the Foundation's selection of the treatment schools was not randomized, a single difference estimator between treatment and control schools would lead to biased effects of the program. The danger of bias stems from the fact that students in selected schools may systematically differ from the students in the non-selected schools. One initial difference between the treatment and control schools that would lead to selection bias is that some control schools were not selected because of having a computer laboratory. A difference in difference estimator would eliminate any selection bias and lead to consistent estimates by assuming that the time trend is the same for both groups of schools,[10] and that the unobservable characteristics of the students are time invariant.

Y_i is defined to be the outcome variable for student i (computer use, time allocation, etc.). T=0 is defined as the baseline period and T=1 as the post-intervention period. D=1 denotes the students

[10] To support this assumption, the control schools were chosen from the same districts as the treatment schools such that local trends can be expected to be equivalent.

that belong to the treatment schools and D=0 denotes the students in the control schools. Therefore, the difference in difference average treatment effect on the treated (ATT) will be:

$$ATT_i = [E(Y_{11i} \mid D_i=1, T=1) - E(Y_{10i} \mid D_i=1, T=0)] - [E(Y_{01i} \mid D_i=0, T=1) - E(Y_{00i} \mid D_i=0, T=0)] \quad (1)$$

A generic regression used to estimate the difference in difference average treatment effect on the treated is:

$$Y = \alpha + \beta D + \delta T + \gamma DT + \phi X_0 + \varepsilon \quad (2)$$

Where X_0 is a set of baseline control variables. The only requirement for using this structure is having repeated cross sections of data, the parameter γ captures the ATT. However, given that we were able to follow the same individuals over time, a panel data strategy that will provide better estimates can be used. To use this strategy, the outcome variables are now determined by the following structure:

$$Y_{it} = \alpha + \beta D_i + \delta T + \gamma D_i T + \phi_t X_i + \mu_i + \varepsilon_{it} \quad (3)$$

Where μ_i represents any unobservable fixed effects for individual i, and the effects of the baseline control variables, ϕ_t, are allowed to change in time. By subtracting the baseline period from the post-intervention period at the individual level, any time-invariant fixed effects are eliminated, resulting in the following equation:

$$\Delta Y_i = \delta + \gamma D_i + \sigma X_i + \eta_i \quad (4)$$

Where σ is equal to $\Delta\phi$ and η_i is equal to $\Delta\varepsilon_i$. Since D_i is the dummy variable indicating treatment, γ will indicate the average treatment effect on the treated. The preferred specification uses Control 19 as the control group, because of the balanced number of observations. However, since there is

the possibility that the assumption of same time trends does not hold for students in schools with a computer laboratory, the regression is also estimated with Control 10 as the reference group. To improve the accuracy of the estimates, a broad set of pre-program control variables are added, which include age of the child, age squared of child, age of the parent,[11] gender of the child, gender of the parent, gender of the head of the household, educational completion of the parent, monthly income, number of members in the household, number of children in the household, having a computer at home, having internet connectivity at home, student having ever used a computer, other family member knowing how to use a computer, school year, number of classrooms in the school, having a library in the school, teacher to student ratio, a dummy variable for rural area, and a dummy variable for the district.

To test for heterogeneous effects of the program, an interaction term is included into equation (4), consisting of the treatment dummy variable and a pre-program observable variable. It is tested whether the program has different effects for different school grades, across genders, for households that already had a computer, and for households in which the parent had completed at least secondary schooling. As a robustness check, equation (2) is estimated using a pooled cross section, which allows to increase the sample size as observations that exist in only one period can now be included. All the regressions are estimated using OLS and the standard errors are clustered at the school level.

6 Results

6.1 Computer Usage

This first subsection estimates the effects of treatment on weekly computer usage. Estimates are presented in Table 4. Students who belonged to the program used a computer at home approximately three additional hours more than their counterparts. This result is consistent using either Control 10 or Control 19 as the control group, and using information reported either from the students or from the parents. At the same time, students in the program used a computer outside their home for approximately two additional hours. The research did not indicate any significant

[11] Age, gender and education of the parent refer to the parent who filled the survey.

effects on computer usage by other family members. Table 5 indicates the students' specific uses of the computers. The results suggest that the program significantly increased the likelihood that the students used a computer to browse the internet, do homework, self-learn online, draw, and play videogames. These results are consistent using either control group.

6.2 Time Allocation

This subsection describes how the program affected the time allocation of both the student and the family members. Using information from the parental questionnaire, Table 6 shows that the program led to a decline in the amount of time students spent doing homework of about one hour. The results also indicate that the program did not seem to lead to any changes in the amount of time spent by the parents helping the student with homework, or by the student in performing home duties. The program seemed to reduce the time that the student engaged in outdoor activities by approximately one hour.

6.3 Test Scores

Table 7 illustrates that the study did not detect statistically significant effects on the mathematics and cognition tests. For the case of the mathematics test, the results show a negative yet insignificant effect on treatment status. This result was consistent with and without the addition of control variables. On the other hand, the cognition test shows a negative yet insignificant effect when control variables are not included, and the effect became positive yet still insignificant when the controls were added.

6.4 Heterogeneous Effects

This subsection discusses whether or not the results from technology access varied across different populations by studying if the effects generated by the OLPC program presented subgroup heterogeneity. The effects are estimated for younger and older students, across genders, for households that already had access to a computer, and for households with higher levels of education.

In Table 8, the odd columns show the ATT coefficient of equation (4) after the addition of an interaction term between the treatment dummy variable the 4 different sub-groups, i.e., the level effect of the treatment sub-group not being interacted. The even columns indicate the coefficient of the interaction term, which denotes the heterogeneous effects for each specific subgroup (the magnitude of the increase or decrease of the effect compared to the sub-group not being interacted). Column 2 shows how the students in grades 1 through 4 use the computer less time outside of the household, i.e., the older students use the computer more time outside of their household. Column 4 indicates that male students use the computer more than female students at home. In column 6, it stands out that the hours of use by other members is significant if the household already had a computer pre-program. This means that the other family members who already knew how to use a computer used the laptop. No different changes are found contingent on the parent having completed secondary education.

Table 9 illustrates how students in the lower grades seemed less likely to use the computer for reading, while males seemed to be less likely to use the computer to do homework. No effects are found on the changes from having a computer at home at baseline or from the parent having completed secondary education. In Table 10, the heterogeneous effects on time allocation are indicated. The results suggest that the students in the lower grades use the computer more to do homework than did their upper class counterparts. It also seems that the parents of these younger students spent more time helping them with their homework. No differential effects on time allocation were found based on computer possession or the parent's educational attainment.

6.5 Robustness

Because the Foundation did not choose treatment and control schools randomly, a robustness check was conducted, the difference in difference estimator was calculated utilizing kernel propensity score matching. Table 11 presents the results of the kernel propensity score matching difference in difference estimation using the panel data and Control 19. The estimators are very similar both in magnitude and in significance when compared with the difference in difference estimator alone.

6.6 Attrition

One problem identified in the data collection stage was that the rate of attrition was not balanced across the treatment and control groups. The response rates were around 99 percent for the treatment group, and around 80 percent for the control group. For an individual in the treatment group, the database has the baseline and post-intervention observation approximately 92 percent of the time. The missing 8 percent mostly came from students who transferred out of or into the school during this study period. In the control group, the panel gathered both observations approximately two-thirds of the time; since in each round about 20 percent did not respond, and this 20 percent was not necessarily comprised of the same students across both periods. In order to determine if those students who were missing were similar across groups, the students that appeared in the baseline survey, but did not appear in the post-intervention survey were identified. Subsequently, a logit model on the students' baseline observable characteristics, with a dummy variable for attrition as the dependent variable was estimated. Table 12 illustrates how treatment significantly affected attrition in a negative way, i.e., it was more likely for the students in the control group to be attritors. However, with the sole exceptions of age and age squared, this research did not detect other significant effects from observable characteristics, therefore no large differences in the unobservables are to be expected.

7 Conclusions and Discussion

This paper analyzed the short-term effects of an OLPC program that in addition to donating laptop computers to each student in eligible primary schools, also provided school connectivity and periodic follow-up visits to guarantee the year-around functioning and maintenance of the program. By incorporating the analysis of the effects on intermediate outcomes, this research contributes to the literature by providing empirical evidence from all the stages through which an OLPC program affects the learning of the beneficiaries. This research estimated the effects of a student having access to a laptop computer on the student's total usage, specific uses, time allocation, and test scores, enabling us to better understand the ways in which the laptops generate outcomes, as well as which outcomes should be expected.

One year after the implementation of the program, the results indicate that the treated students used a computer 5 hours more per week than their non-treated counterparts. The results also suggest that the male students used the computer for more time than females, and that the older students used the computer for more time outside the household than the younger students. An unexpected finding is that the computer usage of other family members remained unchanged. When checking for heterogeneous effects, the estimates show that the only case in which other family members shared the computer was when the household had a computer before the program. These results suggest that during the intervention other family members did not use the computer because they did not know how to use it.

The findings also indicate that students in the program were significantly more likely to use a computer to browse the internet, do their homework, learn by themselves, draw, and play videogames. These results provide evidence that when students participate in a program that provides internet connectivity, they are able to learn how to use diverse applications, which results in a more technologically skilled and informed student population. In line with the existing literature (see Vigdor and Ladd 2010; Malamud and Pop-Eleches 2011; Fairlie and Robinson 2013), the findings also show that the increase in students' use of computers seemed to lead to no change or a decrease in the amount of time that they spent doing homework and performing outdoor activities, reinforcing the view that parental guidance is fundamental to ensure that the laptop computer is used in a productive way and for the child to stay healthy.

The results described in this paper regarding school performance are also consistent with those described in the existing OLPC literature (see Cristia et al. 2012; Sharma 2012; De Melo et al. 2014) in which the provision of laptops without guided use to match courses in the existing school curriculum does not lead to effects on test scores, at least in the short term. However, it is important to differentiate The Conectándonos Program from other OLPC initiatives because this program focused on the quality of the program, and included teacher trainings on how to use the XO laptop and provided periodical computer repair, rather than on distributing the maximum number of computers or providing connectivity to every school. The particularities of this intervention the external validity of the results obtained in this evaluation, especially when they are compared with those of other OLPC interventions that focus more on providing increased numbers of computers.

This results described in this paper have policy-making implications. The research empirically demonstrates how a program that provides connectivity and functioning computer equipment, and ensures that it work throughout the year, led to a very high rate of and diverse type of computer usage. NGOs and governments should revise the implementation methods of OLPC programs because the findings suggest that spending on infrastructure, repairs, and training teachers results in students using the laptop computers in a significantly more productive way. A very relevant finding of this research is that parents and siblings who did not know how to use a computer did not share the computer with the student. Therefore, to increase the population that benefits from this type of program, implementing organizations should provide computer training sessions to an expanded audience, including parents at the beginning of the school year, and also distribute the XO computers that come with a standard sized keyboard and adult-friendly applications.

OLPC programs have high implementation costs and their effects can be difficult to track. Accordingly, policymakers in developing countries should plan the evaluation designs of large-scale interventions in tandem with implementation, keeping in mind that the quality of the evaluation depends on the participants' response rates during the data collection process. A timely assessment of this type of intervention will enable implementing organizations to correct the program's flaws before they compromise large monetary investments. The experience described in this paper was fortunate because by creating a condition for participants to receive, treatment the Foundation created an incentive for the students and parents to provide reliable information that yielded a very rich panel of data. Thus, during the design stages, potential implementing organizations should consider making a condition of treatment, or even eligibility for treatment, that participants provide the information necessary to evaluate these programs.

As a final point, it is recognized that this paper has the limitation that it studies the program only one year after it began. Longer-term evaluations are required to gain a comprehensive understanding of the many outcomes that do not exist, or that are impossible to capture, in the short run. Further research is needed to determine if continuing and expanded access to information is going to change the views of the students and their parents. The data collection for this research was conducted in a way in which individuals can be tracked over time; newer waves of data will shed more light on the mid-term effects of the OLPC program, on students' and parents' aspirations, and, ultimately, on final critical outcomes of participants' occupational choices.

References

Angrist, J. & Lavy, V. (2002). “New Evidence on Classroom Computers and Pupil Learning.” *The Economic Journal*, 112: 735-765.

Banerjee, A., Cole, S., Duflo, E. & Linden, L. (2007). “Remedying Education: Evidence from Two Randomized Experiments in India.” *Quarterly Journal of Economics*, 122.3, 1235-1264.

Barrera-Osorio, F. & Linden, L. (2009). “The Use and Misuse of Computers in Education: Evidence from a Randomized Experiment in Colombia.” Policy Research Working Paper 4836, The World Bank.

Behrman, J., Parker, S., & Todd, P. (2005). “Long-Term Impacts of the Oportunidades Conditional Cash Transfer Program on Rural Youth in Mexico.” N 122 Ibero-America Institute for Economic Research, 2005.

Beuermann, D., Cristia, J., Cruz-Aguayo Y., Cueto, S., & Malamud, O. (2012). “Home Computers and Child Outcomes: Short-Term Impacts from a Randomized Experiment in Peru.” Inter-American Development Bank Working Paper Series No. IDB-WP-382.

Carrillo, P. E., Onofa, M., & Ponce, J. (2011). “Information Technology and Student Achievement: Evidence from a Randomized Experiment in Ecuador.” IDB Working Paper No. 78. Available from: http://ssrn.com/abstract=1818756

Cristia, J., Ibarraran, P., Cueto, S., Santiago, A., & Severin, E. (2012). “Technology and Child Development: Evidence from the One Laptop per Child Program.” Inter-American Development Bank Working Paper Paper Series No. IDB-WP-304.

De Melo, G., Machado, A., & Miranda, A. (2014). “The Impact of a One Laptop per Child Program on Learning: Evidence from Uruguay.” IZA Discussion Papers, No. 8489.

Fairlie, R. W., Beltran, D. O., & Das, K. K. (2010). “Home Computers and Educational Outcomes: Evidence from the NLSY97 and CPS.” *Economic Inquiry*, *48*(3), 771-792.

Fairlie, R. W., & Robinson, J. (2013). “Experimental Evidence on the Effects of Home Computers on Academic Achievement Among Schoolchildren.” (No. w19060). National Bureau of Economic Research.

Glewwe, P. & Kremer, M. (2006). “Schools, Teachers and Educational Outcomes in Developing Countries.” In *Handbook of the Economics of Education*, edited by Eric A. Hanushek and Finis Welch. Amsterdam: North Holland, 943-1017.

Hanushek, E. (1997). “Assessing the Effects of School Resources on Student Performance: An Update.” *Educational Evaluation and Policy Analysis*, 19.2 (1997): 141-164.

Jensen, R. (2007). “The Digital Provide: Information (Technology), Market Performance and Welfare in the South Indian Fisheries Sector.” *Quarterly Journal of Economics*, 122(3), p. 879 − 924.

Jensen, R. (2010). “The (Perceived) Returns to Education and the Demand for Schooling." *Quarterly Journal of Economics*, 125(2), p. 515-548.

Lai, F., Luo, R., Zhang, L., Huang, X., & Rozelle, S. (2015). "Does Computer-Assisted Learning Improve Learning Outcomes? Evidence from a Randomized Experiment in Migrant Schools in Beijing." *Economics of Education Review*, *47*, 34-48.

Malamud, O. & Pop-Eleches, C. (2011). "Home Computer Use and the Development of Human Capital Outcomes." *Quarterly Journal of Economics* 126: 987-1027

Ministry of Education Culture and Science, Education Evaluation Center of Mongolia and World Bank. (2008). "Mongolian National Assessment of Primary Education Mathematics and Reading." Rural Education and Development Project. Ulaanbaatar City.

Mo, D., Swinnen, J., Zhang, L., Yi, H., Qu, Q., Boswell, M., & Rozelle, S. (2013). "Can One-to-One Computing Narrow the Digital Divide and the Educational Gap in China? The Case of Beijing Migrant Schools." *World Development*, *46*, 14-29.

Muralidharan, K., Das, J., Dercon, S., Habyarimana, J., Krishnan, P. & Sundararaman, V. (2012). "School Inputs, Household Substitution, and Test Scores." *American Economics Journal: Applied Economics.*

Nugroho, D., & Londsale, M. (2009). "Evaluation of OLPC Programs Globally: A Literature Review." Mimeograph. Australian Council of Educational Research.

Parker, S., Rubalcava, L., & Teruel, G. (2007) "Evaluating Conditional Schooling and Health Programs." *Handbook of Development Economics* 4: 3963-4035.

Schultz, P. (2004). "School Subsidies for the Poor: Evaluating the Mexican Progresa Poverty Program." *Journal of Development Economics* 74.1: 199-250.

Sharma, U. (2012). "Can Computers Increase Human Capital in Developing Countries? An Evaluation of Nepal's One Laptop per Child Program." Working Paper.

United Nations, General Assembly. (25 September 2015), *Transforming our World: the 2030 Agenda for Sustainable Development*, A/RES/70/1 p.21. Available from: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

Vigdor, J. L., & Ladd, H. F. (2010). *Scaling the digital divide: Home computer technology and student achievement* (No. w16078). National Bureau of Economic Research.

The World Bank Group. (2012). "ICT for Greater Development Impact: Sector Strategy". Viewed 6/5/12. Available from: http://siteresources.worldbank.org/EXTINFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/WBG_ICT_Strategy-2012.pdf

Appendix

Figure 1 The XO Laptop

Source: http://laptop.org/en/laptop/index.shtml

Figure 2 Map of the 4 Treatment Districts

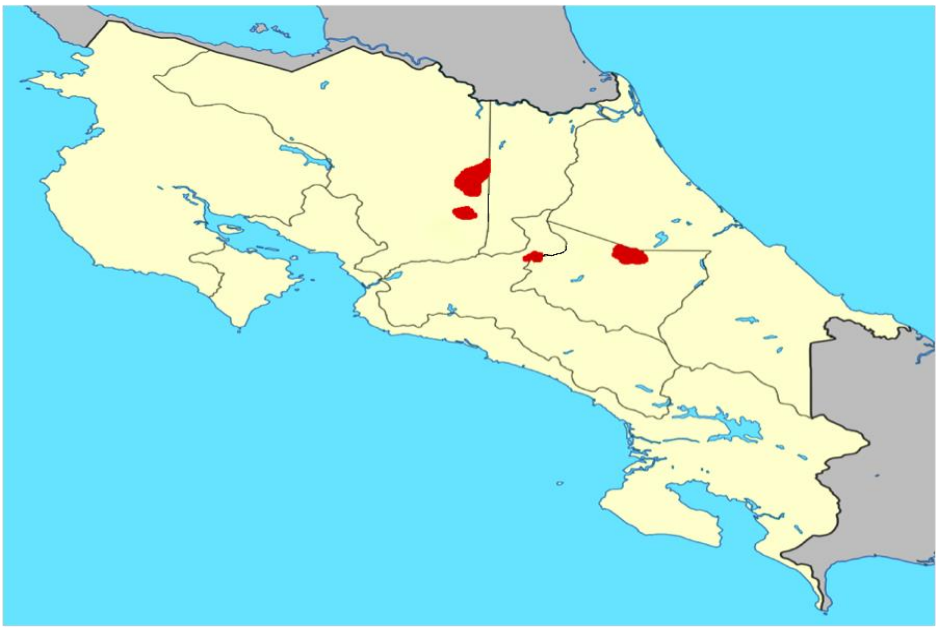


Figure 3 Timeline of the Data Collection

November 2011	February 2012	November 2012	February 2013	April 2013
Control Schools were Surveyed	Treatment Schools were Surveyed Laptops were Distributed	All 6th Graders were Surveyed	All Schools were Surveyed Laptops were Distributed	5th & 6th Graders were Tested

Table 1 Baseline Characteristics Treatment and Control Schools

School	Treatment Status	Total Students	Total Teachers	Number of Classrooms	Library	Computer Laboratory	Water & Electricity
District: Rio Cuarto							
Río Cuarto	Treatment	304	14	8	Yes	No	Yes
IDA La Victoria	Treatment	55	5	3	No	No	Yes
Santa Isabel	Treatment	119	6	5	No	No	Yes
San Rafael	Treatment	124	5	3	No	No	Yes
La Flor	Control10	38	2	1	No	No	Yes
Carrizal	Control10	40	5	2	No	No	Yes
El Carmen	Control10	50	4	3	No	No	Yes
IDA Los Lagos	Control10	64	5	3	No	No	Yes
La Españolita	Control10	48	3	2	No	No	Yes
La Tabla	Control19	98	3	2	No	Yes	Yes
Santa Rita	Control19	293	14	8	No	Yes	Yes
José M. Herrera	Control10	216	9	3	No	No	Yes
District: San Isidro							
La Laguna	Treatment	55	3	2	No	No	Yes
Silvia Montero	Treatment	159	10	6	No	No	Yes
Mario Aguero	Treatment	85	5	3	No	No	Yes
Carbonal	Treatment	98	7	3	No	No	Yes
Enrique Riba	Treatment	114	7	5	No	No	Yes
Luis Sibaja	Control19	237	9	6	No	Yes	Yes
Itiquis	Control19	240	9	6	Yes	Yes	Yes
Timoleón Morera	Control19	164	9	4	No	Yes	Yes
District: Santa Teresita							
Carlos Luis Castro	Treatment	54	8	3	No	No	Yes
Palomo	Treatment	25	3	1	No	No	Yes
Jorge Rossi	Treatment	23	2	1	No	No	Yes
Guayabo Abajo	Control10	62	5	2	No	No	Yes
Cimarrón	Control10	73	5	2	No	No	Yes
Colonia Guayabo	Control10	42	6	3	No	No	Yes
Santa Teresita	Control19	133	9	5	Yes	Yes	Yes
El Cas	Control19	110	4	2	No	Yes	Yes
District: Curridabat							
Jose M. Zeledón	Treatment	125	4	4	No	No	Yes
La Lía	Treatment	95	9	3	No	No	Yes
Yerbabuena	Treatment	113	9	3	No	No	Yes
Cipreses	Control10	43	2	2	No	No	Yes
Carolina Bellelli	Control19	243	14	6	Yes	Yes	Yes
Quebrada Fierro	Control19	179	8	5	No	Yes	Yes
Treatment Group		1550					
Control 10 Group		710					
Control 19 Group		1700					

Source: Quirós Tanzi Foundation. Note: Control 19 includes the original set of Control 10 schools plus 9 additional schools that already had computer laboratories.

Table 2 Baseline Characteristics - Information from Parents

	Full Sample (1)	Treatment (2)	Control 10 (3)	Control 19 (4)	Full Sample 10th Percentile (5)	Full Sample 90th Percentile (6)	(2)=(3) p-value (7)	(2)=(4) p-value (8)
Age of the Parent	36.23	36.02	36.31	36.45	27.00	47.00	0.55	0.24
	(8.27)	(8.39)	(8.44)	(8.22)				
Male Respondent	0.26	0.27	0.23	0.29			0.08	0.45
	(0.44)	(0.45)	(0.42)	(0.45)				
Number of Household Members	4.90	4.97	4.74	4.93	3.00	7.00	0.02	0.66
	(1.73)	(1.75)	(1.63)	(1.75)				
Number of Kids in the Household	1.90	1.99	1.87	1.86	1.00	3.00	0.07	0.02
	(1.20)	(1.16)	(1.23)	(1.22)				
Male Head of the Household	0.72	0.73	0.70	0.72			0.28	0.55
	(0.45)	(0.45)	(0.46)	(0.45)				
Monthly Income of Household	450.66	434.56	457.10	435.45	160.00	800.00	0.19	0.47
	(291.342)	(260.35)	(338.72)	(288.10)				
Monetary Expenditure on Student	44.80	43.64	41.46	42.32	10.00	100.00	0.62	0.65
	(33.55)	(33.32)	(31.59)	(32.99)				
Monetary Expenses on Other Kids	76.09	73.07	68.59	74.36	20.00	160.00	0.36	0.64
	(72.32)	(67.47)	(72.01)	(73.34)				
Ownership of a Computer at Home	0.32	0.28	0.31	0.29			0.37	0.81
	(0.47)	(0.45)	(0.46)	(0.45)				
Having Internet at Home	0.21	0.18	0.20	0.19			0.35	0.40
	(0.40)	(0.38)	(0.40)	(0.39)				
Weekly Hours of Student on Home Duties	3.06	3.05	3.26	3.40	0.00	7.00	0.31	0.06
	(4.10)	(3.89)	(4.43)	(4.62)				
Weekly Hours Parents Helping with Homework	5.19	5.60	5.00	4.95	1.00	10.00	0.02	0.00
	(4.46)	(4.47)	(4.24)	(4.65)				
Weekly Computer usage of the Student	2.12	2.15	1.55	1.99	0.00	7.00	0.01	0.33
	(3.71)	(4.05)	(2.66)	(3.38)				
Student has ever used a Computer	0.58	0.53	0.47	0.58			0.05	0.01
	(0.49)	(0.50)	(0.50)	(0.49)				
Anyone in Household has used a Computer	0.67	0.61	0.62	0.66			0.73	0.03
	(0.47)	(0.49)	(0.49)	(0.47)				
Weekly Computer usage of other members	4.24	4.28	3.86	3.90	0.00	12.00	0.39	0.31
	(8.56)	(8.76)	(8.34)	(8.20)				
Want Child to Stay in the Same County	0.81	0.83	0.81	0.76			0.43	0.00
	(0.39)	(0.38)	(0.39)	(0.42)				
Weekly Hours of Student on Outdoor Activities	5.90	6.78	5.61	5.22	0.00	14.00	0.00	0.00
	(6.07)	(6.77)	(4.93)	(5.43)				
Weekly Hours of Student on Homework	5.74	6.14	5.29	5.55	1.00	10.00	0.00	0.00
	(4.48)	(3.88)	(4.07)	(5.12)				
Encourage Student to use a Computer More	0.92	0.96	0.89	0.92			0.00	0.00
	(0.27)	(0.20)	(0.31)	(0.27)				
Observations	3174	1517	616	1657				

Data: OLPC Costa Rica Baseline (1st Wave). Ho: No difference in means.

Table 3 Baseline Characteristics - Information from Students

	Full Sample (1)	Treatment (2)	Control 10 (3)	Control 19 (4)	Full Sample 10th Percentile (5)	Full Sample 90th Percentile (6)	(2)=(3) p-value (7)	(2)=(4) p-value (8)
Age	9.55	9.26	9.81	9.80	7.00	12.00	0.00	0.00
	(2.03)	(2.07)	(2.16)	(1.99)				
Male Respondent	0.52	0.54	0.56	0.51			0.39	0.21
	(0.50)	(0.50)	(0.50)	(0.50)				
Wants to Stay in the Same County	0.71	0.75	0.75	0.67			0.94	0.00
	(0.45)	(0.43)	(0.43)	(0.47)				
School Enjoyment	9.12	9.26	9.16	9.00	7.00	10.00	0.23	0.00
	(1.63)	(1.33)	(1.70)	(1.85)				
Hours of Computer Usage at Home	1.94	1.85	1.04	2.22	0.00	6.00	0.00	0.04
	(4.20)	(3.88)	(3.15)	(4.77)				
Hours of Computer Usage outside Home	1.06	0.60	0.61	1.41	0.00	2.00	0.90	0.00
	(2.85)	(1.89)	(2.18)	(3.14)				
Observations	3174	1517	616	1657				

Data: OLPC Costa Rica Baseline (1st Wave). Ho: No difference in means.

Figure 4 Access to Technology

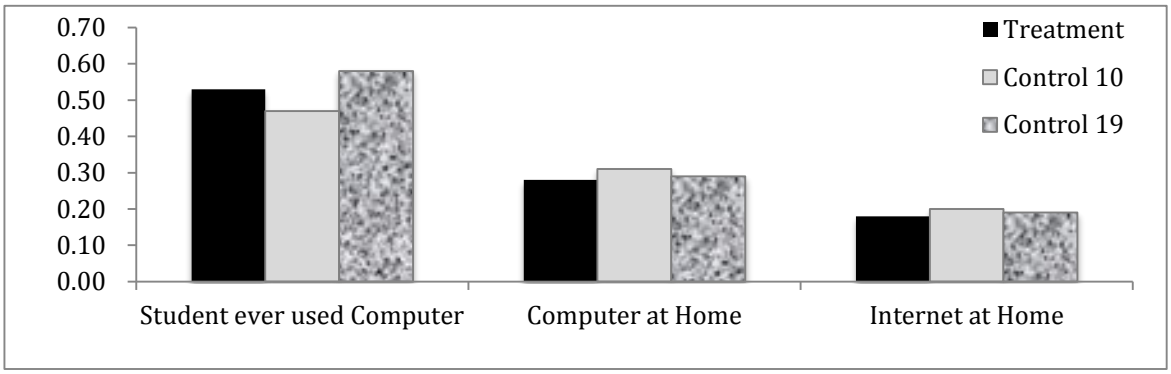


Figure 5 Educational Objective for the Child

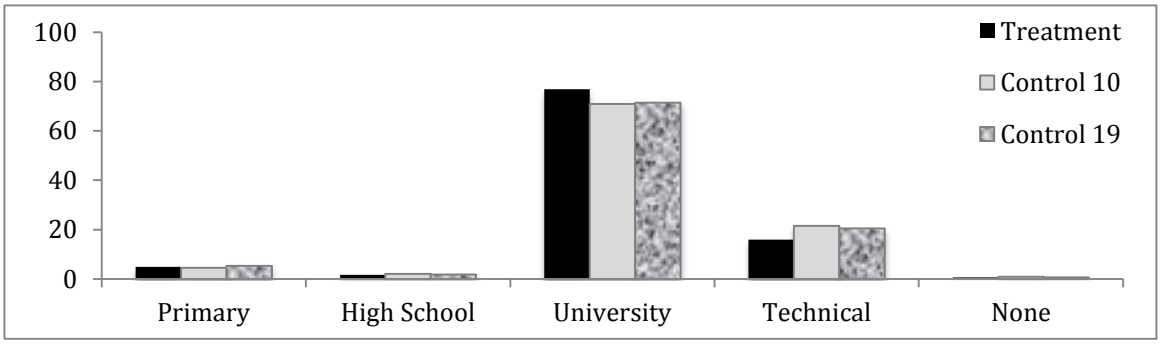
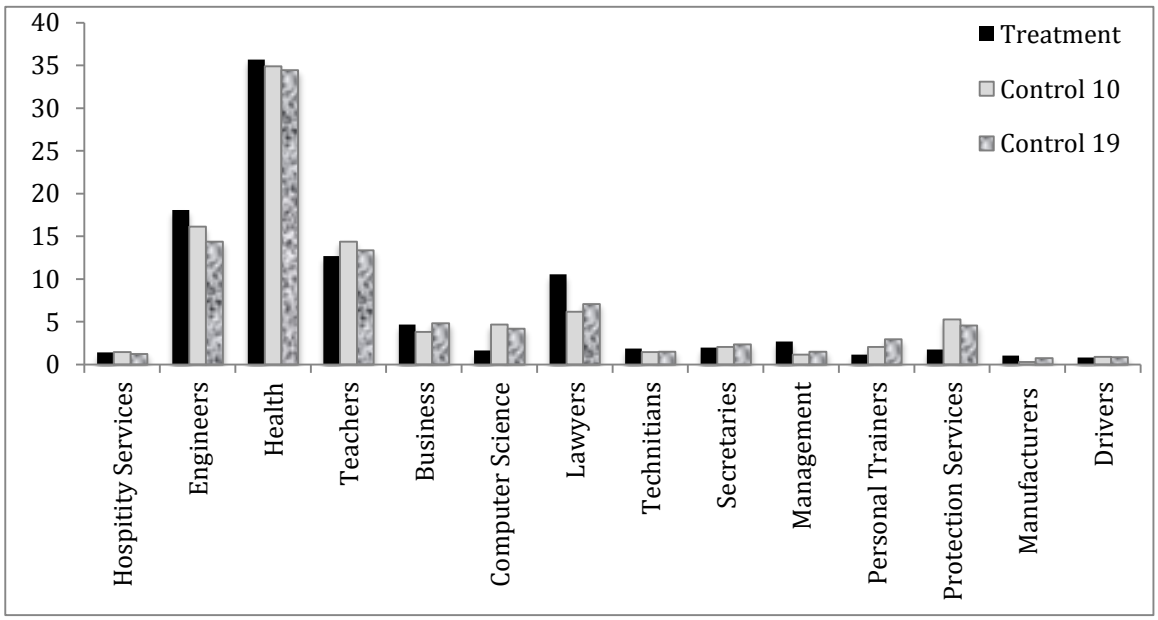


Figure 6 Desired Profession of the Parents for the Students



Source: OLPC Costa Rica Baseline (1st Wave).

Table 4: Effects of the OLPC Program on Weekly Computer Use

	Control 10	Control 19	Baseline Mean
	(1)	(2)	(3)
Student Survey			
Weekly hours of use at home	3.116	2.705	1.94
	(0.710)***	(0.337)***	(4.20)
Weekly hours of use outside	2.581	1.769	1.06
	(0.718)***	(0.333)***	(2.85)
Parent Survey			
Weekly hours of use by the student	2.714	2.561	2.12
	(0.820)***	(0.344)***	(3.71)
Weekly hours of use by others	-0.509	-0.258	4.24
	(0.606)	(0.735)	(8.56)
Control Variables	Yes	Yes	
Observations	2074	2590	

Notes: Panel data estimation. The variables on the left are the outcome variables. The coefficients denote the ATT and the standard errors are robust and have been clustered at the school level. Column (1) uses Control 10 as the control schools; column (2) uses Control 19 as the control schools. Column (3) indicates the pre-program means and standard deviations for the full sample of treatment and control schools. Control variables include: age, age squared, school year, age of the parent, gender of child, gender of respondent, education completion of parent, gender of the head of the household, monthly income, size of the household, number of kids in the household, having computer and/or internet at home before program, student and/or someone in the household knowing how to use a computer before the program, ratio of teachers to students, number of classrooms, library dummy, rural dummy and district dummy.* Significant at 10% ** significant at 5% *** significant at 1%.

Table 5: Effects of the OLPC Program on Specific Computer Uses

	Control 10	Control 19
	(1)	(2)
Student Survey		
Uses for Internet	0.279	0.179
	(0.089)***	(0.051)***
Uses for Homework	0.288	0.044
	(0.089)***	(0.061)
Uses for Self-Learning	0.210	0.085
	(0.093)**	(0.053)*
Uses for Reading	0.334	0.162
	(0.091)***	(0.058)***
Uses for Drawing	0.417	0.214
	(0.091)***	(0.063)***
Uses for Playing Games	0.500	0.299
	(0.093)***	(0.064)***
Uses for Phone calls	0.017	0.007
	(0.022)	(0.017)
Control Variables	Yes	Yes
Observations	2074	2590

Notes: Panel data estimation. The variables on the left are the outcome variables (yes=1, no=0). The coefficients denote the ATT and the standard errors are robust and have been clustered at the school level. Column (1) uses Control 10 as the control schools; column (2) uses Control 19 as the control schools. Control variables include: age, age squared, school year, age of the parent, gender of child, gender of respondent, education completion of parent, gender of the head of the household, monthly income, size of the household, number of kids in the household, having computer and/or internet at home before program, student and/or someone in the household knowing how to use a computer before the program, ratio of teachers to students, number of classrooms, library dummy, rural dummy and district dummy. *Significant at 10% ** significant at 5% *** significant at 1%.

Table 6: Effects of the OLPC Program on Weekly Time Allocation

	Control 10	Control 19	Baseline Mean
	(1)	(2)	(3)
Parent Survey			
Weekly hours of student doing homework	-0.896	-1.059	5.74
	(0.656)	(0.366)***	(4.48)
Weekly hours helping student with homework	-1.061	-0.296	5.19
	(0.610)*	(0.305)	(4.46)
Weekly hours of student doing home duties	0.464	0.386	3.06
	(0.857)	(0.324)	(4.10)
Weekly hours student performing outdoor activities	0.548	-0.952	5.90
	(0.898)	(0.558)*	(6.07)
Control Variables	Yes	Yes	
Observations	2074	2590	

Notes: Panel data estimation. The variables on the left are the outcome variables. The coefficients denote the ATT and the standard errors are robust and have been clustered at the school level. Column (1) uses Control 10 as the control schools; column (2) uses Control 19 as the control schools. Column (3) indicates the pre-program means and standard deviations for the full sample of treatment and control schools. Control variables include: age, age squared, school year, age of the parent, gender of child, gender of respondent, education completion of parent, gender of the head of the household, monthly income, size of the household, number of kids in the household, having computer and/or internet at home before program, student and/or someone in the household knowing how to use a computer before the program, ratio of teachers to students, number of classrooms, library dummy, rural dummy and district dummy. * Significant at 10% ** significant at 5% *** significant at 1%.

Table 7: Test Scores

	Math Test 5th Graders		Cognition Test 6th Graders	
	(1)	**(2)**	**(3)**	**(4)**
Treatment	-5.131	-5.303	-8.008	2.865
	(7.496)	(6.636)	(5.758)	(6.667)
Age		8.965		-21.795
		(8.875)		(18.322)
Age Squared		-0.304		0.799
		(0.431)		(0.909)
Male		1.843		2.620
		(2.544)		(3.832)
Education Completion Parent		0.916		1.096
		(0.931)		(1.411)
Male Head of Household		5.593		-2.879
		(4.030)		(4.182)
Monthly Income		-0.005		0.004
		(0.006)		(0.006)
Size of Household		-0.540		-0.772
		(0.902)		(1.541)
Children in the Household		0.283		0.983
		(1.172)		(1.568)
Computer at Home		4.211		1.451
		(3.310)		(5.806)
Internet at Home		2.265		-5.361
		(4.770)		(6.95)
Has Used Computer		4.211		2.451
		(3.311)		(6.695)
Others Have Used Computer		2.586		2.419
		(3.562)		(4.425)
District Control Variables	No	Yes	No	Yes
Observations	201	167	182	145

Notes: Test Score is the outcome variable. The coefficient for Treatment denotes the ATT, the standard errors are robust and have been clustered at the school level. Cross sectional data.
* Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 8: Heterogeneous Effects of the OLPC Program on Weekly Computer Use

	Treatment	Treatment* Grades 1-4	Treatment	Treatment* Male	Treatment	Treatment* Computer	Treatment	Treatment* Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Student Survey								
Weekly hours of use at home	2.927	-0.458	1.888	1.569	2.712	-0.019	2.711	-0.024
	(0.518)***	(0.612)	(0.521)***	(0.718)**	(0.385)***	(0.532)	(0.395)***	(0.649)
Weekly hours of use outside	2.368	-1.242	1.423	0.677	1.852	-0.231	1.808	-0.149
	(0.435)***	(0.445)***	(0.385)***	(0.458)	(0.432)***	(0.521)	(0.367)***	(0.323)
Parent Survey								
Weekly hours of use by the student	2.272	0.599	2.848	-0.760	2.253	0.866	2.627	-0.255
	(0.497)***	(0.593)	(0.565)***	(0.847)	(0.463)***	(0.616)	(0.412)***	(0.571)
Weekly hours of use by others	-0.325	0.136	0.201	-0.886	-1.133	2.441	-0.342	0.321
	(0.793)	(0.694)	(0.843)	(0.823)	(0.739)	(0.943)**	(0.718)	(0.845)
Observations	2590	2590	2590	2590	2590	2590	2590	2590

Notes: Panel data estimation. The variables on the left are the outcome variables. The coefficients of the odd columns denote the ATT after the inclusion of the interaction term, i.e. the level effect for the treated subgroup that is not being interacted, while the coefficients of the even columns denote the heterogeneous (increase or decrease) additional treatment effect by subgroup. The 4 subgroups are: student belonging to grades 1 through 4, gender, household having a computer pre-treatment and parent having at least secondary education completed. The standard errors are robust and have been clustered at the school level. For all regressions the control group used was Control 19 and control variables were included. * Significant at 10% ** significant at 5% *** significant at 1%.

Table 9: Heterogeneous Effects of the OLPC Program on Specific Computer Uses

	Treatment	Treatment* Grades 1-4	Treatment	Treatment* Male	Treatment	Treatment* Computer	Treatment	Treatment* Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Student Survey								
Uses for Internet	0.172	0.016	0.156	0.046	0.183	-0.009	0.179	0.002
	(0.052)***	(0.049)	(0.051)***	(0.052)	(0.058)***	(0.066)	(0.056)***	(0.058)
Uses for Homework	0.053	-0.017	0.114	-0.131	0.052	-0.022	0.055	-0.043
	(0.055)	(0.073)	(0.066)*	(0.050)**	(0.732)	(0.051)	(0.067)	(0.065)
Uses for Self-Learning	0.101	-0.034	0.068	0.023	0.078	0.017	0.087	-0.011
	(0.061)*	(0.051)	(0.060)	(0.052)	(0.055)	(0.055)	(0.056)	(0.046)
Uses for Reading	0.203	-0.083	0.167	-0.011	0.152	0.028	0.157	0.018
	(0.061)***	(0.042)*	(0.063)**	(0.048)	(0.066)**	(0.054)	(0.060)**	(0.051)
Uses for Drawing	0.242	-0.060	0.223	-0.025	0.200	0.038	0.197	0.061
	(0.065)***	(0.061)	(0.062)***	(0.040)	(0.068)***	(0.048)	(0.064)***	(0.051)
Uses for Playing Games	0.319	-0.039	0.287	0.017	0.323	-0.064	0.287	0.046
	(0.060)***	(0.069)	(0.073)***	(0.054)	(0.073)***	(0.054)	(0.066)***	(0.067)
Uses for Phone calls	-0.007	0.029	0.014	-0.010	0.019	-0.031	0.001	0.025
	(0.021)	(0.264)	(0.018)	(0.019)	(0.020)	(0.032)*	(0.017)	(0.023)
Observations	2590	2590	2590	2590	2590	2590	2590	2590

Notes: Panel data estimation. The variables on the left are the outcome variables. The coefficients of the odd columns denote the ATT after the inclusion of the interaction term, i.e. the level effect for the treated subgroup that is not being interacted, while the coefficients of the even columns denote the heterogeneous (increase or decrease) additional treatment effect by subgroup. The 4 subgroups are: student belonging to grades 1 through 4, gender, household having a computer pre-treatment and parent having at least secondary education completed. The standard errors are robust and have been clustered at the school level. For all regressions the control group used was Control 19 and control variables were included. * Significant at 10% ** significant at 5% *** significant at 1%.

Table 10: Heterogeneous Effects of the OLPC Program on Weekly Time Allocation

	Treatment	Treatment* Grades 1-4	Treatment	Treatment* Male	Treatment	Treatment* Computer	Treatment	Treatment* Educated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Parent Survey								
Weekly hours of student doing homework	-1.566	1.035	-1.122	0.134	-0.842	-0.614	-1.004	-0.220
	(0.526)***	(0.619)*	(0.543)**	(0.639)	(0.406)**	(0.392)	(0.417)**	(0.507)
Weekly hours helping student with homework	-0.795	1.016	-0.166	-0.226	-0.255	-0.114	-0.208	-0.337
	(0.388)**	(0.396)**	(0.456)	(0.684)	(0.360)	(0.348)	(0.337)	(0.448)
Weekly hours of student doing home duties	0.228	0.327	0.677	-0.576	0.266	0.340	0.363	0.089
	(0.411)	(0.321)	(0.437)	(0.497)	(0.342)	(0.383)	(0.322)	(0.395)
Weekly hours student on outdoor activities	-0.938	-0.029	-0.984	0.158	-1.073	0.347	-0.985	0.128
	(0.719)	(0.665)	(0.589)	(0.674)	(0.591)*	(0.393)	(0.523)*	(0.567)
Observations	2590	2590	2590	2590	2590	2590	2590	2590

Notes: Panel data estimation. The variables on the left are the outcome variables. The coefficients of the odd columns denote the ATT after the inclusion of the interaction term, i.e. the level effect for the treated subgroup that is not being interacted, while the coefficients of the even columns denote the heterogeneous (increase or decrease) additional treatment effect by subgroup. The 4 subgroups are: student belonging to grades 1 through 4, gender, household having a computer pre-treatment and parent having at least secondary education completed. The standard errors are robust and have been clustered at the school level. For all regressions the control group used was Control 19 and control variables were included. * Significant at 10% ** significant at 5% *** significant at 1%.

Table 11: Robustness Check - Propensity Score Matching Difference in Difference

	(1)
Weekly hours of use at home	2.309
	(0.571)***
Weekly hours of use outside	1.808
	(0.291)***
Weekly hours of use by the student	2.440
	(0.510)***
Weekly hours of use by others	0.683
	(0.906)
Uses for Internet	0.204
	(0.053)***
Uses for Homework	0.086
	(0.057)
Uses for Self-Learning	0.076
	(0.065)
Uses for Reading	0.241
	(0.070)***
Uses for Drawing	0.295
	(0.049)***
Uses for Playing Games	0.292
	(0.063)***
Uses for Phone calls	-0.013
	(0.028)
Weekly hours of student doing homework	-1.997**
	(0.759)
Weekly hours helping student with homework	-0.442
	(0.442)
Weekly hours of student doing home duties	0.636*
	(0.337)
Weekly hours student performing outdoor activities	-1.041
	(0.795)
Observations	3731

Notes: Kernel propensity score matching difference in difference estimation utilizing panel data. The variables on the left are the outcome variables. The coefficients denote the ATT and the standard errors are robust and have been clustered at the school level. Pre-treatment covariates include: age, age squared, school year, age of the parent, gender of child, gender of respondent, education completion of parent, gender of the head of the household, monthly income, size of the household, number of kids in the household, having computer and/or internet at home before program, student and/or someone in the household knowing how to use a computer before the program, ratio of teachers to students, number of classrooms, library dummy, rural dummy and district dummy. The control group used is Control 19. * Significant at 10% ** significant at 5% *** significant at 1%.

Table 12: Differential Attrition

	(1)	(2)
Treatment	-0.259	-0.258
	(0.064)***	(0.042)***
Age		-0.351
		(0.085)***
Age Squared		0.020
		(0.004)***
Male		0.002
		(0.112)
Education Completion Parent		0.011
		(0.006)
Male Head of Household		-0.036
		(0.030)
Monthly Income		-0.000
		(0.000)
Size of Household		-0.002
		(0.006)
Children in the Household		0.005
		(0.011)
Computer at Home		0.024
		(0.029)
Internet at Home		-0.044
		(0.022)
Has Used Computer		0.010
		(0.027)
Others Have Used Computer		-0.034
		(0.028)
Number of Classrooms		0.017
		(0.019)
District Control Variables	No	Yes
Observations	2990	2442

Notes: The outcome variable is a dummy for attrition. The coefficients denote the probability to attrit; the standard errors are robust and have been clustered at the school level. * Significant at 10%; ** significant at 5%; *** significant at 1%.