

## **The educational impact of the XO computers in Peru**

*It's not a laptop project. It's an education project. – Nicholas Negroponte*

The One Laptop Per Child (OLPC) program has tried to bring information technology to schools in developing countries. The idea behind the program is that children's access to computers and the internet should be a right instead of a privilege. OLPC has therefore created a cheap, durable laptop, and has tried to disseminate it across the developing world. At the beginning of this year Uruguay proudly announced that their objective of giving one XO laptop to every child in Uruguay had been met, a process which cost 0.25% of the country's gross domestic product. Similarly, Antigua and Guyana have recently signed deals to bring one laptop to every child in their respective nations.

To date, there is no rigorous empirical investigation of whether children who use the XO laptops in their education perform better academically than those who do not. This is an essential bit of information in calculating the cost-benefit analysis of the program. This project seeks to answer that particular question. Matching XO laptop deployment data from Peru with standardized test scores, I will find whether or not the use of these machines has any educational effect on the children that use them. Although the laptops are relatively cheap, they still represent a significant cost for governments who have to choose how to best allocate their small budgets. Given the qualitative analysis of the OLPC program put forward by Derndorfer (2010) which highlights the lack of infrastructure, teacher training, and government support, I suspect that the effect will be at best positive but insignificant. This would not mean that OLPC is a bad idea altogether. Instead, different arguments need to be used to support the mass distribution of laptops throughout schools.

### The OLPC program and Peru

OLPC is a non-profit organization whose mission it is to deliver cheap laptops to the world's poorest children for the purposes of education. This project was born at MIT in 2005, and by 2006 the XO laptop, at the time known as "the \$100 laptop," was released. The laptops were designed to endure harsh climate and treatment conditions. They could be charged through a variety of means, like solar power or motion power as well as through regular electrical outlets. The laptops were designed to make internet connectivity possible, so the wireless mesh network was introduced, such that every laptop with an internet connection would act as a router for other laptops which did not have a direct connection. Lastly, the laptops were not installed with Windows, choosing instead various forms of Linux like Sugar, the Operating System used in Peru. Although this presented a reduction in production costs, it also presented a challenge for teachers who had limited experience with computers and had only been exposed to Windows systems.

Mass production and deployment ensued. OLPC has been criticized for its questionable development priorities, as many believe that there are more fundamental development projects worth undertaking, such as the provision of clean water. Furthermore, OLPC does not involve itself with the implementation of laptops into the countries' educational curricula. They have a "walk away" policy, since OLPC chairman Nicholas Negroponte believes that the technology is so easy to use that "you can give kids XO laptops and just walk away."<sup>1</sup> Implementation, then, is left up to the Ministry of

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<sup>1</sup> From OLPC website:  
[http://www.olpcnews.com/people/negroponte/new\\_negropontism\\_you\\_can\\_give\\_kids\\_xo\\_laptops.html](http://www.olpcnews.com/people/negroponte/new_negropontism_you_can_give_kids_xo_laptops.html)

Education of the recipient country. XO computers are provided for school use, but they are also intended to serve as home computers. Indeed, it is expected that other members of the family, such as parents, will also benefit from having a computer in the home.<sup>2</sup>

This drive-by approach has important consequences. Among other things, there is a clear lack of communication between OLPC and the Ministries of Education. For example, the stated aim of OLPC is to provide a laptop to all primary students in Peru, a number they claim is around 2.7 million.<sup>3</sup> According to the Peruvian Ministry of Education's census data, however, there over 3.7 million students enrolled in primary school.<sup>4</sup> The OLPC target is mis-calibrated by nearly 40%. All the success reports should thus be viewed under that light. Second, as Derndorfer (2010) describes, the absence of OLPC staff in the recipient country creates an infrastructural vacuum where no support exists for teachers who have to learn how to use, fix, and teach with the laptops.

OLPC nevertheless entered Peru in early 2008 with 260,000 laptops after a brief pilot test in the small village of Arahua.<sup>5</sup> By 2011 there were over 850,000 XO laptops in over 8,000 primary schools. The regions targeted were Lambayeque, Chincha, Puno, Huanuco, and La Libertad. Peru is the fourth most populous country of South America with a population of nearly 30 million inhabitants. Although Spanish is the national language (84% of population), roughly 14% of Peruvians speak Quechua and 2% speak Aymara. The XO laptops, however, only operate in Spanish, and any command required to fix common issues is in English (Derndorfer: 2010). At just over 92%, Peru has one of the highest

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<sup>2</sup> Anecdotal evidence from the OLPC website points to parents using the computers to connect to Google Maps in order to make their business transactions more efficient.

<sup>3</sup> <http://laptop.org/en/children/countries/peru.shtml>.

<sup>4</sup> See <http://escale.minedu.gob.pe/magnitudes-portlet/reporte/cuadro?anio=2&cuadro=20&forma=U&dpto=&dre=>

<sup>5</sup> The pilot consisted of providing laptops to all 46 children in the single-classroom school in the village.

literacy rates in the region,<sup>6</sup> and ranks relatively high on school enrolment rates both in urban and rural areas, both for males and females.<sup>7</sup>

### Previous Research on the Role of Technology in Education

There are many theories that attempt to explain what effect computers may have on educational outcomes such as test scores. Introduction to computers is an introduction to technology, so newly-acquired computer skills may be reflected in more efficient work in terms of time and quality. Furthermore, educational software and the internet provide users with an access to large troves of information that might otherwise be unavailable. Aubrey and Dahl (2008) believe that ICT should even be used in the Early Years Foundation Stage, which is to say children below the age of five, a claim supported by Sweeney and Geer (2010).

The assumption here, though, is that computers will get used for educational purposes. However, gaming and surfing the internet are among the most frequent activities of computer-using children. This feeds a common fear that children may become addicted to the computer, which is linked to repetitive strain injuries, eye strain, increased risk of obesity, and decreased social involvement. Time spent on a computer, then, might be time that may be better used by the child from a development perspective, such as by spending time outside and building personal relationships. It may also be time better used from an academic perspective if the child can focus better and work more efficiently if she does her homework by hand.

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<sup>6</sup> <https://www.cia.gov/library/publications/the-world-factbook/geos/pe.html>

<sup>7</sup> See Urquiola, Miguel and Valentina Calderon (2006) "Apples and oranges: Educational enrollment and attainment across countries in Latin America and the Caribbean," International Journal of Educational Development, Vol. 26, pp. 572{590

Is education technology, then, academically effective? Schachter's 1999 review of the effect of technology in student achievement finds positive results like faster learning rates or higher student satisfaction in the classroom. Regarding achievement, the results are mixed. Some of the studies reviewed find positive results on achievement, and many of these tended to be comprehensive educational programs which included the use of technology. Many also did not use standardized tests. Other studies, like Macho (2005), find no significant effect. There seems to be evidence, however, that technology is more effective when learning objectives and the focus of technology use are very specific.

The results seem to be equally mixed in the 21<sup>st</sup> century. O'Dwyer et al (2005) find that language arts and writing scores increased in Massachusetts 4<sup>th</sup> graders when computers were used to write papers. Scores decreased when computers were used for other tasks (such as preparing presentations), and students' recreational use of technology at home was negatively associated with learning outcomes. However, they were not able to randomize their samples and therefore fail to resolve endogeneity issues.<sup>8</sup> The same authors in 2008 find that computer use had no significant effects on standardized test scores, even when controlling for recreational use of computers.

The story seems to be different with older students. Fairlie and London (2009) find that a randomly selected group of community college students who received free laptops achieved better educational outcomes than the control group, though the effects were relatively small. Students initially living farther from campus benefitted more from the free computers, suggesting that laptops grant higher flexibility in completing tasks. In a later

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<sup>8</sup> i.e. children it may be the case that smarter children use a computer because they were smarter to begin with, not merely because of the potential facilitating effects of the computer. O'Dwyer et al do recognize their inability to randomize as a shortcoming of their paper.

study (2010), Fairlie et al. find that teenagers who had access to computers at home were more likely to graduate than those who didn't, although in their analysis they do not convincingly remove omitted variable bias, which is also present in Fairlie (2005) when he finds an association between computer ownership and school enrolment.<sup>9</sup>

Nevertheless, the general consensus in the literature is that the effects of educational technology are mixed (Palozzi and Spradlin: 2006). This makes a cost-benefit analysis difficult, not least because many of the costs of the program are also not obvious (e.g. academic or telecommunications support). With regards to the benefits, most authors point to the clarity and focus of the educational programs as determinants of success. In evaluating the OLPC program in Peru, then, I am not simply evaluating the effect of XO computers in Peruvian schools but the characteristics of the particular program as well.

The trend is similar in non-English-speaking countries such as Spain, where the deployment of ICT centres are questioned (Cubillo and Rojo: 2009) and Portugal, where the presence of broadband in schools has detrimental effects on high school students' test scores (Belo et al: 2008). Thus, there are at best mixed effects of computerized instruction on test scores, and the evidence from developed countries is not encouraging. However, this may not be the case in developing countries. As Banerjee et al. (2007) argue, computers may replace unmotivated and untrained teachers. They examine the effect of a computer-assisted learning program in India which offered children two hours of computer time per week to play games that involve math problems. They find a positive effect of computer use on math test scores, even though the effect faded over time. Nevertheless, their research suggests that closely targeted computer instruction may be beneficial.

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<sup>9</sup> E.g. it may be the case that children with higher levels of academic ability or children with more "educationally motivated" parents are more likely to have access to a home computer.

Malamoud and Pop-Eleches (2010) evaluate a recent Romanian program which allocated vouchers for the purchase of a home computer to low-income students by estimating the computer's effect on child and adolescent educational outcomes. They find that most of the computer time was spent playing games. They also find that children who (randomly) received a voucher achieved significantly lower school grades in maths, English, and Romanian, but scored significantly higher in computer skills and computer fluency. Furthermore, in a previous 2008 study of the same program, they find suggestive evidence that the having a computer at home was associated with negative behaviour outcomes. Importantly, they find that the presence of parental rules regarding computer use and homework appear to mitigate the effects of computer ownership, but only when it is constructive (encourages doing homework) rather than restrictive (regulating computer use). This suggests two things: the first is that parental monitoring and supervision may be important mediating factors. The second is that such monitoring probably applies to teachers in the classroom too, meaning that computers in the classroom may have positive effects on student educational outcome if teachers are properly trained.

No empirical study has been done on any OLPC program. Antje Breilkopf (2011) has conducted a qualitative analysis of 12 OLPC schools in Peru. She finds that there seems to be an adjustment period on behalf of both students and teachers after the introduction of the laptop, which is extensive given the relative lack of support from the Ministry of Education and the relative lack of initial technological know-how in the village.<sup>10</sup> Laptops were mostly used between 1 and 3 times a week and very rarely on a daily basis. In Grades 1 and 2 they were hardly used because teachers focused their efforts in teaching how to

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<sup>10</sup> Teacher training was clearly lacking, as some teachers had problems just entering and exiting computer programs.

read, and more importantly, write.<sup>11</sup> There were also some significant language barrier problems, as many students spoke Aymara at home and had only begun to learn Spanish at school. Santiago et al. (2010) through the Inter-American Development Bank study find similar results, although they also find that laptop use decreases over time, though they are not able to explain why.<sup>12</sup> There is no doubt that the XO laptops have great potential, but the program is likely over-idealized and not country-specific enough to give children all it can give. (Yujuico: 2011)

### Economic Model

In order to understand what possible effects the OLPC project might have on education, we must take a step back to look at the bigger picture. Consider the following utility maximizing problem:

$$\max_s U(c_0, s) + \sum_{t=0}^T (c_t(s))$$

$c_0$  represents short term consumption,  $s$  represents schooling, and  $\sum_{t=0}^T (c_t(s))$  represents future consumption, which will be a function of current schooling. Schooling, then, should be thought of as a cost in the short term. This could be the utility function of a child, where schooling carries a psychic cost, or of a parent, where schooling represents an opportunity cost. This can be shown in the following budget constraint:

$$c_0 = y^p + (1-s)w^c - sc^{school}$$

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<sup>11</sup> That is one skill that current laptops cannot teach.

<sup>12</sup> The reason is probably that laptops get broken and take a long time to fix. For more on this see Derndorfler (2010)

where  $y^p$  is the total income earned by parent,  $w^c$  is the income earned by the child, and  $c^{school}$  is the cost of schooling. Thus, by sending a child to school consumption decreases because less total income is earned and there are school costs to pay (such as tuition fees, uniform, etc.). Thus, we would expect  $\frac{\delta(U)}{\delta s} < 0$ . In the long term, we would expect to see that consumption is a function of past schooling, and is equal to current wages, that is,

$$c_t(s) = w = f(s).$$

With the introduction of the XO computers, then, we might see three different effects. The first is that the laptops make learning, and hence schooling, more engaging and productive.

Thus, while schooling still represents a cost (i.e.  $\frac{\delta(U)}{\delta s} < 0$ ), it is a burden that is easier to

bear, that is,  $\frac{\partial \frac{dU}{ds}}{\partial OLPC} > 0$ . I argue that this is the primary mechanism through which we see

an effect. Another explanation might be that since the laptops are free, the cost of school decreases as money is no longer spent on other educational materials such as textbooks, i.e.

$\frac{\partial c^{school}}{\partial OLPC} < 0$ . However, since laptops are supplements and not total substitutes, the effect is

likely to be very small. Finally, we might expect to see long-term increases in wages since laptops will allow children to develop their technological skills which will later be highly

valued in the labour market.<sup>13</sup> Thus, we would find that  $\frac{\partial \frac{dw}{ds}}{\partial OLPC} > 0$ . Since OLPC program

has only been in effect for a small number of years, though, we are unlikely to see this effect right now. Thus, we expect the introduction of laptops to ease the burden of

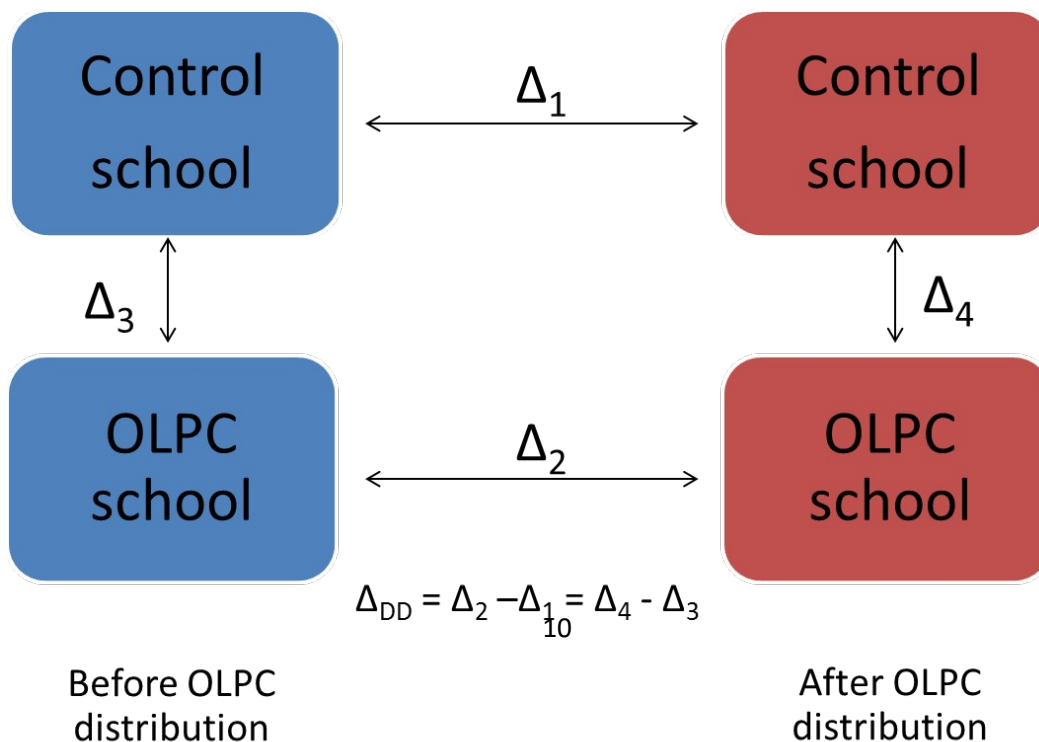
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<sup>13</sup> Thus, the child would benefit from having higher wages, and presumably the parent would benefit from having her child earn higher wages (since she will be taken care of better)

schooling by making it more fun, accessible, and productive. The empirical model will show us how this can translate into higher academic performance.

#### Data and Empirical Model:

The intuition for the experiment is the following: We want to find out whether children who are given laptops perform much better academically than they would have in the absence of the laptops. However, comparing past performance of an OLPC school to its present performance would not necessarily tell us the effect of laptop introduction alone, since external factors, such as changes in government funding of schools, may affect educational outcomes as well. We therefore also need to compare the treatment group to a control group that is also experiencing the same external factors at the same time so that we can single out the OLPC laptop effect. The ideal method to follow, then, is the difference-in-differences approach. In difference-in-differences we compare the difference in academic performance between the treatment group and the control group before the intervention to the difference in academic performance between the two groups after the intervention. The approach is best seen through diagram below.



Formally, we can express this process like this:

$$T_i = \beta_0 + \beta_1 S + \beta_2 L + \beta_3 SL + \epsilon$$

where  $T$  represents test scores,  $S$  represents a dummy variable that captures any differences between treatment and control groups at baseline (i.e.  $\Delta_3$ ),  $L$  represents any difference in a group over time (e.g.  $\Delta_2$ ), and  $SL$  is an interaction of the two. The coefficient we are mostly interested in, then, is  $\beta_3$ , which as stated before is expected to be positive even if it is not statistically significant.

So far this merely describes the theory behind the approach. The reality is a little bit more complicated. The underlying assumption is that the treatment and control groups are similar in all the important ways such that the only noticeable change will be the effect of the intervention in the treatment group (i.e. the only difference is whether or not the schools have laptops). The OLPC program in Peru targeted very poor schools in fairly remote regions. Compared to the control group (i.e. schools that did not receive XO laptops), changes in school performance over time may be due to other external factors such as school infrastructure or the wealth of the region. Therefore, the targeting of the OLPC program is not random from an income perspective. Besides targeting disadvantaged schools, however, there does not seem to be any other criterion at work when choosing which schools were assigned laptops.<sup>14</sup> This means that if we control for these infrastructural differences we should have two comparable groups. Formally, this changes our equation to:

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<sup>14</sup> On the other hand, it is very difficult to actually verify this claim, as data and other information on OLPC distribution in Peru are extremely scarce.

$$T_i = \beta_0 + \beta_1 S + \beta_2 L + \beta_3 SL + \beta_4 Y + \epsilon$$

where  $Y$  is a vector of variables that include average family income of village and infrastructure measures such as average number of electrical outlets or student-to-teacher ratios.

This brings us to the topic of data. Unfortunately there is no one dataset that pulls all the necessary information together. Instead, we have to use three imperfect sources of data in order to try and get a clear picture of the effect of the XO laptops.

*Distribución de Laptops OLPC and the ESCALE interactive map*

The first thing we need to identify is which schools received laptops. The most detailed source of data for this comes from the Peruvian OLPC website itself, [www.perueduca.edu.pe](http://www.perueduca.edu.pe). It details the number of laptops distributed to date; the names of the school districts (Unidad de Gestion Educativa Local) that received laptops; the number of laptops that each district received; and the code of the educational institutions that received laptops within each district. The data show that the laptops were distributed across the whole of Peru. Although it is difficult to ascertain whether or not the spread of the laptops is “as if random” from the data alone (Peru Educa does not say), given the almost uniform coverage in each region we should imagine that the selection bias lies almost entirely on infrastructure.

This dataset has severe limitations. The first is that it groups together all the deployments over time. In other words, it does not say which schools received laptops in 2008, 2009, or 2010. This does not allow us to tease out the real effect of laptops over time. In fact, assuming that laptops have a positive effect on academic performance, this effect

will be muted if we group all the different distribution batches together. In other words, although this should not necessarily change the sign of the effect, this grouping will make statistical significance harder to achieve.<sup>15</sup>

The dataset is also limited since it does not tell us anything about the schools themselves. In fact, the dataset does not even say how many laptops each school received. However, the key to finding out more about the school is the code of the educational institutions that Peru Educa does provide. For example, that same code can be used in an interactive map on the website of ESCALE (Estadística de Calidad Educativa), the statistical branch of the Peruvian Ministry of Education.<sup>16</sup> By inputting the code in the map we can ascertain other characteristics of the school like its name and its exact geographic location. From these two different sources, then, we can essentially create a complete treatment group, even though any additional information on specific schools is absent.

### *ESCALE Censo Escolar*

The ESCALE Censo Escolar is an annual census that collects extensive information about every educational institution in Peru except higher education institutions (universities). The census includes useful data such as number of matriculated students by age and gender. It has limited data on academic performance: the highest level of detail it goes into is the number of students in the class who passed or failed the grade. Although usable, this is a very rough measure of academic performance, and would only help us

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<sup>15</sup> It is also not necessarily the case that the sign of the effect will always be the same. Even if the effect is positive in the long-term, there may be short-term adaptation issues to the laptops that actually make students perform worse.

<sup>16</sup> At the time of writing, the map was under maintenance. However, it was previously access through the following URL: <http://escale.minedu.gob.pe/mapaeducativo/>. The maps do exist in digitized, but not interactive, format, at <http://escale.minedu.gob.pe/carta-educativa>. The use of these maps, however, would be very impractical.

identify those students who either make incredible progress as they move from a failing situation to a passing situation or those who were already on the verge of passing. It would not, for example, tell us anything about those who were performing well and are now performing even better. Nevertheless, with a large enough sample even this data should be able to show us some sort of effect.

The dataset also contains data on the schools themselves. This includes parameters such as whether or not the school has electricity or an internet connection, two factors which are very important for an XO laptop education.<sup>17</sup> Here the data once again shows limitations. There is mass under-reporting in this section. In 2008 there were around 55,000 entries (that is to say, schools). In 2009 there were only 45,000. It is not clear why 10,000 schools disappeared from the record from year to year. Thus, we should handle this data with caution.

Another setback to the census is that it is not possible to identify the schools within the dataset. This is important because it means that we cannot match the schools from the OLPC dataset to the schools in the census. This lack of communication between the two datasets is an obstacle that needs to be overcome if they are to be used.

### *Evaluacion Censal de Estudiantes – UMC*

There exists a third dataset that provides much more detailed metrics on student performance. The *Evaluacion Censal de Estudiantes* by the *Unidad de Medicion de Calidad* (UMC)<sup>18</sup> is an annual math and reading comprehension test given to second

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<sup>17</sup> Derndorfer mentions that almost 5% of the schools that received laptops do not formally have electricity (and only 1.4% are connected to the Internet). Among those that are recorded as having electricity, this may mean having a single outlet in the principal's office, which is insufficient to power a whole school's worth of laptops.

<sup>18</sup> Unit of Quality Measurement - another branch of the Peruvian Ministry of Education

graders in schools across the country. It measures whether a 2<sup>nd</sup> grade student is performing at 2<sup>nd</sup> grade standards, 1<sup>st</sup> grade standards, or below 1<sup>st</sup> grade standards. Although the evaluation is not censal in that it does not cover every school for logistical reasons, the sample has been selected so that it is representative of the Peruvian school population. The sample is also large enough that, coupled with the relatively high penetration of laptops to date (almost 10%),<sup>19</sup> there should be a large enough sub-sample of schools that received the UMC test and have XO laptops.

The problem is once again that it is presently not possible to identify the actual schools that received the test, meaning that we cannot identify which of the schools that received the UMC test were OLPC schools. Similarly, the UMC data does not “communicate” with the ESCALE dataset because they use different ways of identifying the schools. This means that we cannot benefit both from the detail of the evaluations from UMC and the detail of the characteristics of the schools from ESCALE.

Nevertheless, assuming we can find a way to coordinate the three different datasets, we have everything we need to get some worthwhile results. The UMC test scores should be the dependent variable. The presence of XO laptops in the school between 2008 and 2010 should be our main independent variable (baseline year should be 2007). Although an initial model should test these two variables alone, other models should incorporate control variables. These control variables will attempt to make each school as similar to each other as possible. Therefore, these control variables should include student-to-teacher ratios, total number of students in the school, access to internet, access to electricity, and type of

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<sup>19</sup> This is calculated using the “number of laptops distributed” in OLPC data divided by number of primary students from ESCALE data.

settlement.<sup>20</sup> Through these different models we should be able to identify the effect of the XO laptops on the average academic performance of students.

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<sup>20</sup> A rural school and an urban school are likely to have to have infrastructural differences that set them apart. These do not just include access to electricity and internet, but may also include proximity to the students' homes and the level of interaction with the rest of the community. The type of settlement is classified in the ESCALE census data with a number ranging from 11 (city) to 29 (agrarian cooperative)

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Data Sources:

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Evaluación Censal de Estudiantes UMC: [http://www2.minedu.gob.pe/umc/index2.php?v\\_codigo=52&v\\_plantilla=2](http://www2.minedu.gob.pe/umc/index2.php?v_codigo=52&v_plantilla=2)

Distribución de Laptops OLPC: [http://www.perueduca.edu.pe/olpc/OLPC\\_Dist.html](http://www.perueduca.edu.pe/olpc/OLPC_Dist.html)

ESCALE interactive map: <http://escale.minedu.gob.pe/mapaeducativo/>