Learning Outcomes of One Laptop per Child in Paraguay: The Importance of Social Support

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Abstract

This article describes the differences in reading and mathematics scores between children enrolled in the One Laptop Per Child project in Paraguay, financed and run by the non-governmental organization Paraguay Educa, and other children nearby. In 2010 and again in 2013, we administered two tests to all third-grade and sixth-grade students in the program, those who were about to join the program in 2010, and a similar sample in nearby schools not in the program. Based on the differences between the two tests, we did not see the advances in 2013 that we were hoping for. We hypothesize that this is because much of Paraguay Educa's celebrated support structure had been dismantled in 2012 due to lack of funding.

Introduction

This article discusses the learning outcomes observed for what is considered one of the most successful One Laptop Per Child (OLPC) projects (Bender, Kane, Cornish, & Donahue, 2012; Derndorfer, 2010; Warschauer & Ames, 2010), a project in Paraguay with 10,000 of OLPC's "XO" laptops. One Laptop Per Child (OLPC), first announced in 2005, is one of the largest interventions in computer-based learning currently underway. Two and a half million of OLPC's XO laptops are in use around the world, 85% of them in Latin America, and the project continues to inspire other education and development interventions.

Despite OLPC's scope, there has not been a rigorous formal assessment of the educational effects, particularly in reading and mathematics, of any OLPC project to date. While some in the project (Bender et al., 2012; Papert, 1993) and in the educational community more broadly have decried formal assessments as not measuring the right thing, they are nevertheless the standard yardstick by which educational projects are currently assessed. This article reports on the results of an assessment of literacy and mathematical reasoning done in 2010 and 2013 in Paraguay as part of a larger study on the social and educational effects of OLPC (Ames, 2013).

In collaboration with Paraguay Educa, the non-governmental organization (NGO) in charge of the project in Paraguay, we designed two exams that tested reading comprehension and mathematical reasoning, one for third-grade students and one for sixth-grade students. We administered this exam to all third- and sixth-grade students in the program in 2010 (Phase 1), a group of students about to join the program (Phase 2), and a control group in nearby schools. We administered the same tests in the same schools in 2013. One large difference in the program between 2010 and 2013 was that in 2010, Paraguay Educa's project was in full-swing with full-time teacher trainers in every school and a full-time technical support staff, while in 2013, the teacher trainer program had been discontinued and the support staff significantly cut back due to lack of funding.

The baseline (2010) scores of the 25 Phase 2 schools, which were largely small and rural schools, were around 6% lower across all grades and subjects than the eleven relatively larger and more urban Phase 1 schools and the control schools. Between 2010 and 2013, these scores improved slightly, though the only moderately significant difference was in third-grade reading, which improved 3.1%. We found that the relatively higher scores in the Phase 1 schools and the control schools mostly held steady between 2010 and 2013, with the exception of sixth grade

mathematics, which had a statistically significant improvement in Phase 1 schools and decrease in the control schools.

Based on the lack of more significant change between 2010 and 2013, we hypothesize that the initiatives that were discontinued, though expensive, were in fact vitally important to the success of the program as a whole. While the 2013 results are disappointing, they do indicate that the expectations that often govern education and development projects continue to be myopic, emphasizing short-term gains over long-term sustainability, despite ample evidence that such approaches do not work (Ames, 2013). These findings have implications for scholars, policy-makers, and (perhaps most importantly) funding agencies who establish the scope of education and development projects.

Background

In 2008, two well-connected Paraguayans, both fresh out of college (one from Tufts University in Massachusetts, one from the Catholic University in Asunción), were captivated by the promises of the MIT-based One Laptop Per Child project and formed a non-governmental organization (NGO) called Paraguay Educa to bring OLPC's distinctive laptops to their country. In September 2008, newly-formed Paraguay Educa explained their motivations for giving OLPC's XO laptops to Paraguayan children in an article in *ABC Color*, one of Paraguay's two major newspapers (ABC Color staff, 2008). Their professed dreams for technologically savvy, passionate learners with their own laptops was inspiring to many who became involved with the project, but not unique. In fact, much of the vision expressed in that 2008 news article was drawn directly from OLPC's promotional materials, from the list of benefits including low power consumption, customized learning software, rugged construction, and a state-of-the-art screen

(OLPC staff, 2011) to the project's Five Core Principles of child ownership, low ages, saturation, connection, and free/open source (OLPC staff, 2012).

In the second half of 2008, Paraguay Educa's founders used this captivating story about the promise of OLPC laptops to secure financial, political, and infrastructural support from a number of local and international sources. With the help of a donation from the philanthropic arm of Swift Group, a European banking conglomerate, they purchased 4000 first-generation "XO" laptops from OLPC, which arrived in early 2009 (ABC Color staff, 2008). For "Phase 1" of the project in April 2009, Paraguay Educa distributed these XOs to all students in grades one through six (ages six through twelve) and their teachers in eleven schools[1] in the small municipality of Caacupé, fifty kilometers east of the capital Asunción. In May 2011, they purchased and gave an additional 5000 second-generation XO laptops to all primary-school students and teachers in the other 25 schools in the municipality in "Phase 2" of the project, and gave another 1000 laptops to first-and second-grade students in Phase 1 who were not yet in elementary school in 2009, reaching full saturation in the area with 10,000 laptops.

Because Paraguay's small project of XO laptops is run by a NGO rather than the Department of Education, it also appears to be more adaptable and less tied to election schedules and results than the larger projects in Uruguay and Peru. The programmer who co-founded Paraguay Educa, in fact, contributed upstream to the XO's software himself and was able to build a team of others who could do the same in the first few years of the project. Paraguay Educa also installed significant infrastructure in each school to support the laptops, including WiMax towers, a (caged) school server, (also caged) wifi access points, and power outlets in the main office and every classroom. They also provided laptop repair staff.

[1] Note that two of these schools shared the same campus, one a large public school and one a subsidiary private school sponsored by an evangelical church in Texas, U.S.A.

Though Paraguay's OLPC project is not the largest, it is nevertheless illustrative of larger trends in OLPC. In particular, though much of OLPC's early publicity either implicitly or explicitly named African children as its imagined beneficiaries, relatively few XO laptops are in use in African countries. According to OLPC's website (Klein & Holt, 2012), only 6% of XOs in use around the world are in Africa, 90% of those in Rwanda, a deployment about which little is known by the broader research community. In contrast, projects in ten Latin American countries account for 85% of the XOs in use around the world (Klein & Holt, 2012; Warschauer & Ames, 2010). Peru and Uruguay host the largest projects (over 500,000 laptops); Argentina and Mexico host medium projects (25,000-60,000 laptops); and regions in Nicaragua, Paraguay, Colombia, Guatemala, Brazil, and Costa Rica host small projects of 1500-10,000 laptops each.

Classroom Laptop Use and Teacher Training

Paraguay Educa's staff decided from the beginning to encourage classroom laptop use with teacher training. They conducted a two-week teacher training session in December 2008 for all teachers in the eleven Phase 1 schools (Paraguay Educa staff, 2008). However, many teachers described struggling with even basic operations such as searching the web or checking their email and they consequently hardly used the laptops during the first year.[2]

In response, toward the end of the first year of the project, Paraguay Educa formed an education division, an occurrence that is fairly unique among OLPC deployments larger than pilot programs. They hired several employees to work in their Asunción office on curriculum development, educational outreach, and assessment, and 16 teacher trainers who worked full-time in the eleven Phase 1 schools to help teachers incorporate the laptop into their curriculum.

[2] Some of this difficulty was due to context: based on a survey I conducted with teachers during my fieldwork, before receiving an XO, only one in four teachers had a computer at home, only one in eight had Internet access, and less than half had *any* access to or experience with a computer (though all had mobile phones and nearly all had televisions).

Trained and paid by Paraguay Educa, these trainers began when the school year started in February 2010. They served as local mouthpieces for Asunción-based Paraguay Educa by promoting the idea of the laptop as a learning device and giving concrete suggestions for lessons that incorporated the XO. Having these full-time trainers in every school made a huge difference for classroom laptop usage, according to teachers' and students' usage reports, my own observations, and teachers' recollections at the end of the 2010 school year.

Paraguay Educa's Director of Education was keenly interested in facilitating an independent evaluation of the project. Thus, Paraguay Educa provided a testing ground for OLPC's ideas under very good conditions of support and interest. Moreover, Paraguay Educa was larger in scale and less prone to the special treatment of a pilot project in just a classroom or two, and was interested in evaluation.

One of Paraguay Educa's primary concerns about the teacher trainers was how such a program could scale, with Paraguay Educa's limited budget, as more schools were added to the deployment. The nationwide deployment in Uruguay benefitted from a generous budget that enabled every school to hire a full-time technical liaison whose duties were much like Paraguay Educa's trainers, though my own limited observations[3] indicated that Uruguay struggled more than Paraguay did to adequately train this large full-time support staff. But Uruguay had thousands of schools involved in its deployment; Paraguay started with just eleven in Phase 1, expanding to 36 in May 2011 for Phase 2.

The teachers from the 25 Phase 2 schools received significantly more, and more practical, training than their Phase 1 counterparts. They received their laptops nearly a year before their students did, attended three weeks of intensive training with Paraguay Educa's teacher trainers –

[3] Based on day-long visits to two schools in August 2009 and two schools in November 2010 within an hour and a half travel time from Uruguay's capital Montevideo

who by then had extensive experience using the XOs pedagogically – over winter break in July 2010, and attended ongoing supplemental training after that. However, when laptops were given to their students in May 2011, they would not benefit from having a full-time trainer on-site, and Phase 1 schools would no longer have full-time trainers either. In May 2011, Paraguay Educa's fifteen trainers began to split their time between multiple schools, visiting each only once or twice a week, much like Paraguay Educa's roving technical support staff. Then, after the 2011 school year, Paraguay Educa was not able to secure additional funding for the trainers, and only one was kept on to support after-school programs for a small group of motivated students. Classroom use of the laptops, as a result, went down considerably at this point. There was also little funding for the technical support staff or for spare parts, so the number of broken laptops began to increase more quickly. Thus, the Phase 1 and Phase 2 schools were largely on their own with regards to the laptop program beginning in 2012.

Methods

In collaboration with Paraguay Educa's director of education, María de la Paz ("Pacita") Peña, we developed two multiple-choice exams of 30 questions each, one for third-grade students and one for sixth-grade students, that tested basic literacy (*i.e.* identifying the main character and understanding the storyline of a short story) and basic numeracy (*i.e.* relationships between numbers, spatial relationships, and sequences). In 2010 we administered these tests to all third- and sixth-grade students in the program, all third- and sixth-grade students about to join the program, and a comparable and similarly-sized group of third- and sixth-grade students from schools nearby that had no plans of joining the program, for a total of 2085 students. We again administered the same tests to the same schools in 2013 with 2565 students. By testing all third- and sixth-graders in the experimental conditions and an approximately equal number in a control

group in 2010 and 2013, we have more than enough data points for statistical significance and eliminate some of the biases that can occur when studying only a subset of students.

We designed the testing conditions to enable several kinds of comparisons. First, using the results of the testing in 2010 only, we could compare the eleven schools that were in the laptop program at that time (Phase 1) with the 43 schools that were not (Phase 2 and control). While we would not be able to completely eliminate the possibility of confounding factors in this between-groups comparison, we could control for known confounds including school size, whether the school was urban or rural, and whether the school was public or private.

Then, after the 2013 test, we could compare the differences between 2010 scores and 2013 scores for the three conditions: Phase 1, which had laptops in both 2010 and 2013; Phase 2, which did not yet have laptops in 2010 but had them in 2013, and the control, which did not have laptops for either test. We can also conduct a cohort study, testing whether there are any significant differences between the three groups in the changes in scores between the two tests for individual students. For instance, we might expect that the difference for Phase 2 would be greatest, since they went from not having laptops to having laptops between the two tests. Below we list a number of specific hypotheses that we test with the data.

We selected third and sixth grades as suitable benchmarks in the Paraguayan schooling system for several reasons. By the end of third grade, all students are expected to be able to read and write basic Spanish, and at the end of sixth they are promoted to junior high and out of the official laptop program (though students continue to own their laptops and Paraguay Educa has administered some opt-in extracurricular programs for those who are most interested).

The tests were multiple-choice, with four choices per question. Roughly one third of the questions were about reading comprehension – which consisted of one fiction passage and one

nonfiction passage – and two thirds were about mathematical reasoning (equal parts numeracy, patterns/algorithms, and spatial reasoning). Questions were modeled after cognitive reasoning tests for students two grade-levels lower in the United States,[4] and after the 2006 SNEPE, a standardized test previously used in Paraguay and elsewhere in the world. Like the high-school-level PISA test, questions were developed specifically to *not* depend on any specific curriculum (e.g. words or concepts taught in a particular grade), but instead were designed to test general cognitive reasoning. They were also written to be locally appropriate; for example, one short reading passage discussed Paraguayan food.

We validated the third-grade test once and the sixth-grade test twice with the help of a Paraguayan education evaluation expert, Dr. Oscar Serafin. We administered both tests to pilot groups of third-grade and sixth-grade students in October 2010, and Dr. Serafin conducted a validation of the responses. At the end of the validation, each test had a Chronbach's Alpha score of over .7, which is the minimum threshold for reliability of the test. The school that piloted the tests in 2010 was excluded from the analysis as well as the counts below.

In 2010, Paraguay Educa's teacher trainers and other employees administered the test on paper to all third- and sixth-grade students, totaling 2085 students, in 52 schools. The 2010 testing spanned the week of November 22 and 29, the end of the 2010 school year in Paraguay, just before summer vacations started. There were three groups of students who took the test: 576 students in Phase 1 schools who have had laptops since 2009 (treatment 1), 773 students in Phase 2 schools who received laptops the following May (treatment 2), and 724 students in the nearby towns of Atyra, Altos and San Bernardino which have no plans for joining the laptop program (control). The control group included similar proportions of public/private, large/small, and

[4] We chose to model on tests two grade-levels lower because that is the level at which Paraguayan students have historically performed on standardized tests such as the SNEPE compared to students in the United States.

urban/rural schools as the experimental groups. In addition to providing a comparative results to date, this 2010 test provided a baseline measure for a follow-up test with third- and sixth-grade students at the same schools at the end of 2013, five years into laptop use for Phase 1 schools and three years in for Phase 2 schools.

In 2013, Paraguay Educa's teacher trainers and other employees – a subset of the same group that administered the test in 2010 – administered the same test on paper to all third- and sixth-grade students in the same 52 schools, this time totaling 2565 students. The 2013 testing spanned the two weeks of November 4 to 15 (double the time taken in 2010 due to reduced staff to administer tests), the end of the 2013 school year in Paraguay. This time, 848 students were in Phase 1 of the program (treatment 1), 916 students were in Phase 2 of the program (treatment 2), and 801 students were in schools in nearby towns not in the program (control).[5]

Paraguay Educa's employees and I manually entered and cross-validated the 2085 returned tests in 2010 and the 2565 returned tests in 2013. I conducted an analysis of these results using the statistical packages SPSS and R. I excluded blank tests for consistency,[6] resulting in 2071 of 2085 tests given in 2010 and 2472 of 2565 tests given in 2013 being included in the analysis below.

[5] The disproportionate increase in the numbers of students in Phase 1 schools – with 47% more students in third and sixth grades in 2013 than in 2010, compared to 18% more in Phase 2 schools and 10% more in the control schools – was itself a surprising finding, and one for which we do not have a non-speculative explanation. Some may be explained by examiners' more rigorous follow-up in 2013 to have students who missed in-class testing take the test when they returned to school, though this should have increased the numbers in all schools equally. Some may also be due to reduced drop-outs or increased school attendance in Phase 1 schools, or perhaps just more people moving to the town center.

[6] These tests could have been from a student who did not fill anything out or from a student who was absent on the main test day as well as the make-up test days, but still had a paper test put aside by the proctor. Blank tests might also have been not consistently recorded by those entering data, especially between 2010 and 2013. Therefore, I excluded all of them for consistency.

Results

The author conducted Welch two-sample T-tests[7] to evaluate whether the mean exam scores between the treatment group and the control group have a statistically significant difference. These results are broken down by subject (language and mathematics), by grade (third, sixth, and combined), by the year the test was administered (2010 and 2013), and by other factors that could influence score including whether the school was public or private and urban or rural. The author used the statistical analysis package R to conduct the analysis and to generate density plot graphs to visually observe the difference in means and variances.

Results for Phase 1 Schools

Phase 1 schools had laptops in both 2010 and 2013. In 2010, they also enjoyed the support of teacher trainers and technical support staff, support that had mostly been discontinued by 2013. The results of the 2010 test suggest that the OLPC laptop program in Paraguay, as implemented by Paraguay Educa, had achieved modest improvements in third-grade mathematics scores for the Phase 1 students with laptops (N=529) as compared to the control group. We found a moderately significant ($p<0.05$) positive difference in 3rd grade math, with Phase 1 students scoring 3.5% higher than the control. However, we also found a moderately significant ($p<0.05$) *negative* difference in 6th grade math, with Phase 1 students scoring 4.3% worse than the control group. We did not find any statistically significant differences in third- or sixth-grade reading scores between Phase 1 and the control in 2010.

Between Phase 1 and the control in 2013, we found a strongly significant ($p<0.01$) positive difference in scores in 3rd grade math, with Phase 1 schools scoring 5.3% better than the control. We also found a moderately significant ($p<0.05$) positive difference in scores in 3rd

[7] The authors chose this method of analysis because it provides a correction for when the samples in question are not guaranteed to have equal variances (when, for example, the analysis is done between-groups).

grade reading, with Phase 1 schools scoring 3.8% higher than the control. Other subjects and grades did not have statistically significant differences.

Doing a within-group comparison of Phase 1 scores in 2010 and 2013, the only moderately significant ($p<0.05$) difference is that 6th grade math is improved by 3.3% in 2013 as compared to 2010. Because Phase 1 schools were enrolled in the laptop program in both 2010 and 2013, these results do not tell us what the effects of the laptops were. However, they do tell us that if Paraguay Educa did make a difference to this group in 2010, it appeared to continue to do so in 2013. On the other hand, in the control group, where we expected *no* difference between 2010 and 2013, we did in fact observe one moderately significant ($p<0.05$) difference between 2010 and 2013: a *decrease* of 3.9% in 6th grade mathematics.

Overall, these findings, while preliminary, suggested that there were incremental but statistically significant benefits to being part of Paraguay Educa's OLPC laptop program, especially for third-grade mathematics. However, the authors acknowledge the many issues of between-group experimental design in this 2010 analysis, though to reduce such issues a similar number of students from urban/rural schools and large/small schools was included in each group. Furthermore, the authors restricted the analysis to public schools, as public schools are funded and provisioned similarly across the sample while private schools varied widely in wealth and quality.

Moreover, it is impossible to know what actually caused this difference. Perhaps it was tinkering with the laptop itself, but perhaps the teacher training and the lectures and suggestions of visitors from OLPC and elsewhere provided teachers with excuses to reflect on pedagogical practices and to be encouraged to try new classroom arrangements and more child-centered learning models, as well as encouraging ongoing conversations around what worked best, which

teachers were having the most success, and why (Ames, 2013). Even if some of these changes were due to a placebo effect motivated by the laptop's presence, though, the results of the Phase 1 tests in 2010 and 2013 still suggest that this program made a difference.

Results for Phase 2 Schools

The test results in Phase 2 schools was meant to provide more solid evidence of the effects of the laptop. For the test in 2010, the 25 Phase 2 schools did not yet have laptops, and these scores established a baseline. We did find that the mean scores in Phase 2 were about 6% lower than the mean scores in the control group in 3rd grade reading, 3rd grade math, 6th grade reading, and 6th grade math, with all of those differences strongly statistically significant ($p<0.01$). We hypothesize that this is due to the relatively high number of rural schools in Phase 2 as compared to the control.

By the time of the 2013 test, students in Phase 2 schools had had laptops for two and a half years, including most of the 2011 school year, all of the 2012 school year, and all of the 2013 school year. However, as described above, there were significant changes in Paraguay Educa through this time as well. Phase 2 schools had one year of part-time teacher trainer help in 2011, and then two years without systemic support. We found that in 2013, the gap between Phase 2 schools and the control schools had narrowed, with mean scores between 1% and 4% lower than the mean scores in the control group for all categories, but the results are not consistently significant.

By conducting a within-group comparison of the 2010 and 2013 scores in the Phase 2 schools, we are able to more directly establish how reading and mathematics scores changed with the introduction of the laptops. However, we did not see many changes. The only moderately significant ($p<0.05$) difference between 2010 and 2013 Phase 2 test scores is that 3rd

grade reading is improved by 3.1% in 2013 as compared to 2010. We did not observe a difference in reading in sixth grade or mathematics for either grade. This is in contrast to Phase 1 schools, where we saw a consistent difference in third-grade mathematics in both 2010 and 2013.

We hypothesize that Phase 2 schools did not have more benefits to the program because much of the social support structure, which needs ongoing financial support, had been discontinued after the first year of the Phase 2 program.

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