2019 Annual Conference of the Society for Research on Educational Effectiveness

Symposium proposal

Title: "Large-Scale Randomized Evaluations of Technology Applications in Latin America"

Symposium justification: Governments in the United States and all around the world are making large investments in technology programs to increase student learning. Unfortunately, the existing evidence suggests that many of these initiatives have produced limited learning effects. Still, it is clear that technology can play an important role in promoting learning especially if programs are designed to promote behaviors and practices that have shown to be important for educational effectiveness. In this symposium, four large-scale randomized evaluations of technology applications implemented in public schools in Latin America will be discussed.

The first study, titled "Technology and Child Development: Evidence from the One Laptop per Child Program," analyzes a worldwide initiative that seeks to increase learning in the poorest regions by providing personal laptops to students to be used at school and home. The study evaluates the effects of the program in primary schools in poor, rural areas of Peru.

The second study, titled "Do Children Benefit from from Internet Access? Experimental Evidence from a Developing Country," examines the impact of home internet access on students attending primary, low-performing schools in Lima, Peru. The study compares children who were randomly chosen to receive laptops with high-speed internet access to (i) those who did not receive laptops and (ii) those who only received laptops without internet.

The third study, titled "Challenges in Educational Reform: An Experiment on Active Learning in Mathematics," investigates the effects of a program that seeks to promote active learning among secondary school students in Costa Rica. In particular, the study analyzes how this pedagogical innovation may be facilitated (or hindered) by using technological resources in the classroom such as an interactive whiteboard, computers shared by two students or personal laptops for each student.

Finally, the fourth study, titled "Improving Math Learning using Technology: Experimental Evidence from Chile," explores the effects of a program called "Conecta Ideas", which involves that students have two weekly learning sessions in a computer lab. The distinctive feature of this program is that it promotes student engagement throught Math tournaments and collaborative learning.

These four large-scale, well-designed randomized controlled trials seek to analyze how the use of technology affects the development of student skills. In particular, all studies analyze the effects of these programs on academic achievement (Math and Language). Moreover, the first two studies examine whether the introduction of technology affect general cognitive skills measured by psychological tests such as the Ravens Progressive Matrices' test. Taken together these studies show that the different models of technology in education can produce markedly different effects on academic achievement. In fact the first two studies in Peru find that increasing access to computers and internet produced only minors effects on academic and cognitive skills. In contrast, the third study in Costa Rica, showed that technology in education programs can produce even *negative* effects in academic achievement. Finally, the fourth study in Chile suggest that technology in education programs that seek to promote student engagement through tournaments and collaborative learning can produce large positive effects on Math learning.

Study 1: "Technology and Child Development: Experimental Evidence from the One Laptop per Child Program"

Julián Cristia (Inter-American Development Bank)

Pablo Ibarrarán (Inter-American Development Bank)

Santiago Cueto (Grupo de Análisis para el Desarrollo, GRADE)[1]

Ana Santiago (Inter-American Development Bank)

Eugenio Severín (independent consultant)

Background/context: The use of technology in education has been increasing over the past few years in developing countries. However, there are a variety of models by which technology could be incorporated into the classrooms. One of these models, that became very popular during the past decade, was the One Laptop per Child Program (OLPC). This program aimed to improve learning by providing low-cost equipment to children in the developing countries. Previous studies by Sharma (2012) had found no effects in Nepal, but Ferrando et al (2011) found significant results in Uruguay. Other studies have studied the impact of providing computers, typically with no results (e.g. Angrist and Lavy, 2002) or providing access to software designed to improve academic achievement (e.g. Markman and Rouse, 2009), with more positive results. However, this was the first study on the impact of the OLPC program in rural areas in a developing country. This is a significant issue for academia but also for policy purposes, as around 860,000 laptops of this program were purchased by the government of Peru over several years, starting in 2008. The cost of each was 188 US dollars, but there are no estimates of the total cost of implementing the program since its inception (some laptops that are operational still can be found at the schools today).

Research question: What is the impact of the OLPC program on the digital, cognitive, and academic skills of primary students?

Setting: Schools in Peru, selected by the government for intervention given the low index of human development in their communities.

Subjects: Students in 319 primary schools in rural areas in Peru.

Intervention: The program provided each student with a resistant laptop at a relatively low cost. These computers could be used at school and home and included a variety of free software that should support performing a variety of functional tasks (e.g. a word processor and a spreadsheet), help develop cognitive skills (e.g. memory games and programming), music, photograph and video, Wikipedia, and 200 books, among others. However, the laptop did not include specific software linked with academic areas (e.g. reading or mathematics).

Research design: We implemented a randomized controlled trial (RCT): schools were assigned randomly to the treatment (n= 209 schools) and control (n= 110 schools) in Peru, with the collaboration of the Ministry of Education, which implemented the program. The government would not allow for half of the schools to be in each group, thus the difference between them. We checked for compliance (all schools

[1] Presenting autor and contact author (email: scueto@grade.org.pe).

in the treatment group received the program and eight percent of schools in the control schools received the program). We also checked for the comparability of the two groups, using administrative data (sociodemographic and results in standardized tests of reading and mathematics) as well as our own surveys, and found overall that they were similar previous to treatment.

Data collection and analysis: The OLPC program provided with a laptop to every student participating in the program, starting in 2009. The final tests were administered after 15 months of treatment

Findings: OLPC increased access to computers (1.18 per student in the treatment group versus 0.12 in the control). We tested students in digital skills asking them to directly perform a variety of tasks using the laptops and found that most were able to use them in tasks such as opening and saving files and performing a variety of specific tasks with the software. We estimated intention to treat parameters in the comparison between treatment and control groups. We found differences only in cognitive skills (test of progressive matrices, verbal fluency and coding tests) combined, but only at the 10% level of significance (overall effect size=0.11). We found no differences between the groups in reading or mathematics, which was one of the goals of the government when they provided the laptops. We checked for heterogeneity in the results (by gender and grade) and found that in general the non-significant results in achievement hold for all groups. In regard to potential mechanisms, the program did not increase attendance to schools, motivation to learn or reading habits. We also collected logs of use of laptops and found that they were more often used during school hours. Parallel to the RCT design, we carried out a qualitative study in a few schools and found that often times teachers did not incorporate laptops fully into their lessons, but only asked students only to copy material from the board, or students on their own used the laptops but to take photographs, videos, or play games.

Conclusions: The provision of equipment needs to be planned so that they are used as pedagogical resources. The training that teachers received in Peru for the OLPC program often times was only aimed at teaching them how to use the software existing in the laptops, but not how to integrate them into their lessons. However, some of the requirements that the OLPC program planned for (e.g. that students take the laptops home or that schools had access to internet) were not followed in many cases. Over the past few years, many models that use technology in a guided way (e.g. software specifically designed for learning mathematics that may be used by teachers in their lessons as they see pertinent) have been used and seem more promising for increasing the skills of students in poor areas in developing countries.

Study 2: "Do Children Benefit from Internet Access? Experimental Evidence from a Developing Country"

Ofer Malamud (Northwestern University)

Santiago Cueto (Grupo de Análisis para el Desarrollo, GRADE)

Julián Cristia (Inter-American Development Bank)[2]

Diether Beuermann (Inter-American Development Bank)

Background/Context: Despite the rapid worldwide expansion of the internet, large disparities in children's internet access remain. Internet access is practically universal for children in developed countries: over 95% of 15-year old students in OECD member countries report having a link to the internet at home (OECD, 2017). In contrast, access to the internet continues to lag for children in developing countries. For example, less than half of 15-year-old students in Algeria, Peru, and Vietnam report having internet access at home (OECD, 2017). In an effort to alleviate this "digital divide", many government and non-governmental organizations are investing substantial resources to expand internet access to children in developing countries. However, rigorous evidence for the impact of home internet access on children's outcomes is currently limited to developed countries and may not generalize to settings where fewer resources can complement or substitute for technology.

Purpose/Objective/Research Question: This paper provides experimental evidence for the impact of home internet access on a broad range of child outcomes.

Setting: The evaluation was implemented in 14 public, primary, low-performing schools in Lima, Peru.

Population/Participants/Subjects: About 1,800 students participated in the study.

Intervention/Program/Practice: We first provided access to XO laptops for home use to a random sample of 540 children enrolled in grades 3 to 5 at baseline (June/July 2011). Then, among children who received these laptops, we randomly selected about 350 children to receive free high-speed internet access (July/August 2012). The laptops included 32 applications selected by the Ministry of Education of Peru for its national program, and we offered training and manuals on how to use them. We also offered tutorials and manuals to children who received internet access in which we showed them how to take advantage of freely available educational websites created by Peru's Ministry of Education and other online resources, such as Khan Academy and Wikipedia.

Research Design: Individual-level randomized controlled trial.

Data Collection and Analysis: We conducted a follow up survey in November 2012, approximately 17 months after the laptops were initially distributed and 5 months after the provision of internet access. We also conducted an additional follow-up survey in March 2013 to check for longer-run impacts after the summer vacation. In particular, we compare (i) children who were randomly chosen to receive laptops with internet access to (ii) those who did not receive laptops and to (iii) those who only received laptops

[2] Presenting author and contact author (email: jcristia@iadb.org).

without internet. Thus, we are able to estimate the impact of internet access both separately from, and in conjunction with, the impact of the laptops themselves.

Findings/Results: Our interventions were successful in increasing children's access to technology at home and led to substantial improvements in digital skills after just 5 months. Children who were offered internet access were 30 percentage points more likely to have internet at home as compared to those who were not offered internet, whether they had laptops or not. Furthermore, children who were offered internet access scored 0.3 standard deviations higher on a test of internet literacy than those who were not offered internet access, whether they had laptops or not. They also scored 1 standard deviation higher on a test that measured proficiency on the XO laptop compared to those who were not offered laptops, but not significantly different from those children who were offered laptops without internet. In addition, children who were offered laptops (with or without internet) had significant improvements on a Windows-based computer test, suggesting that gains in computer literacy were not only limited to the specific XO platform but transferred to skills for using other types of computers.

Despite the increase in access to technology and the improvements in digital skills, there were no significant effects of internet access on academic achievement. We can rule out impacts larger than 0.08 standard deviations in math and 0.13 standard deviations in reading with 95% confidence when comparing children who were offered internet access to those who did not get laptops. Nor were there any significant effects on a broad set of cognitive skills, as measured by the Raven's Progressive Matrices test, a verbal fluency test, a test of executive functioning, a coding test, a working memory test and a test of spatial reasoning. Similarly, we did not find significant effects on a self-esteem index measured by a self-reported questionnaire. Based on teacher reports, children in the treatment groups were equally likely to exert effort at school when compared with their counterparts in the control group, and there were no differences on grades obtained from administrative school records or in teacher perceptions of children's sociability.

There was also no evidence of improvements when we resurveyed children 8 to 9 months after internet provision following the summer vacation, despite the potential benefits of engaging children with the internet to counteract summer learning loss.

Conclusions: Our results indicate that providing children with access to computers and internet at home (together with some training) effectively closes the gap in digital skills between those with and without home computers and internet. Therefore, to the extent that improving children's digital skills is a relevant goal for an educational system, providing access to computers and internet at home may be one way to achieve this. However, it may also be possible to achieve these gains at a lower cost. For example, Bet et al. (2014) show sizeable increases in digital skills from relatively minor increases in access to shared computers at schools in Peru. There is also some evidence that the provision of school-based internet can generate gains in student learning (Kho, Lakdawala, and Nakasone, 2018; Sprietsma, 2007). Perhaps the utilization of school-based internet is monitored more closely than internet at home. In contrast, increased access to such technology at home which is used mainly for entertainment activities does not appear to improve academic achievement, cognitive or socio-emotional skills, which are arguably the more important outcomes of such interventions.

Study 3: "Challenges in Educational Reform: An Experiment on Active Learning in Mathematics"

Samuel Berlinski (Inter-American Development Bank)[3]

Matias Busso (Inter-American Development Bank)

Background/Context: We created a scalable intervention geared towards allowing students to achieve mathematical competence. That is to say, students' ability to think, reason, argument, and communicate using mathematics. This concept is prevalent in the design of PISA examinations (OECD, 2009) and in curricular reforms in many countries, including Costa Rica and the United States.

There is surprisingly little empirical evidence on the effectiveness of competing teaching approaches in mathematics. A recent report of the National Mathematics Advisory Panel on instructional practices in mathematics concludes: "For none of the areas examined did the Task Group find sufficiently strong and comprehensive bodies of research to support all-inclusive policy recommendations of any of the practices addressed" (Gersten, 2008: 6-189). Among the practices evaluated the panel looked at the use of teacher-centered versus student-centered approaches and the use of technology in the classroom.

Purpose/Objective/Research Question: We created a pedagogical intervention designed to give students a more active role in the learning of geometry in the seventh grade. A key aspect of this change relies on providing students with guided opportunities to explore and discover. In mathematics, a potentially important lever in this process is the use of technology.

Setting: We report the results of an experiment that took place in Costa Rican secondary schools.

Population/Participants/Subjects: We randomly assigned 85 participating schools to treatment and control groups. All students (18,000) and teachers (190) in the seventh grade of these schools participated in the experiment.

Intervention/Program/Practice: The intervention covered the whole geometry unit (one of 3 units of the seventh-grade curricula – about three months of teaching). Treatment schools received the active learning intervention. In addition, to assess the role of technology keeping constant the pedagogical approach, we randomized treatment schools to receive no technology, an interactive whiteboard, a computer lab, or a laptop for every child in the classroom.

We commissioned the design of pedagogical material for this project to local experts advised by a team from a leading international education academic organization. To support teachers and students and with an eye directed at improving fidelity of implementation as well, we created a teacher's manual and a student's workbook (one for every modality of the intervention but none for the control). Technology was introduced through a set of applets (created on a software familiar to Costa Rican teachers) designed to help students and teachers explore the key concepts of the unit.

In coordination with our local partners, we ensured that all the new resources were in place at the time of the implementation and suitable technical support was provided to guarantee that all resources were functional during the experiment. Teachers received 40 hours of on-site and distance training with virtual

[3] Presenting author and contact author (email: samuelb@iadb.org).

support, achieving a 95 percent participation rate. All the teachers in treatment arms received a laptop computer and a manual. All the students in seventh grade (with the exception of the control group) received a workbook.

Research Design: Randomization yielded groups with similar observable characteristics. The experiment was implemented with high fidelity. Materials and equipment were distributed where and when expected. They remained functional throughout the experiment.

Data Collection and Analysis: Geometry learning was the target outcome of the experiment. In collaboration with local and international experts, we designed a psychometrically valid test of geometry to measure the impact of this intervention. The objective of the test was not only to measure the content knowledge of the students but also their mastery of higher-order geometric practices that require, for example, that students pick, compare, justify or refute conjectures and propositions.

With a complex intervention like this one, it is also important to understand how we affected the behavior of students and teachers. Only by understanding these underlying mechanisms can we learn why the target outcome has changed. For this purpose, we collected teacher and student surveys that use scales validated in psychology and educational research to measure class dynamics, teaching practices, attitudes and beliefs. We also collected classroom observations to further attest to the changes reported by teachers and students.

Findings/Results: There were significant changes in class dynamics with more participation from students. Teachers in the treatment arms were open to the innovations we introduced in the classroom. We find that the control group learned significantly more than any of the intervention groups. The students using only the active learning approach learned about 17 percent less of a standard deviation than the status quo. The loss in the group that also received technology was 25 percent of a standard deviation. We also find that the best students were harmed the most by this intervention. Concurrently, their behavior deteriorated and they were less engaged with learning mathematics.

Conclusions: The evidence suggests that teachers went through the motions as prescribed but did not master the innovation in a way that would have allowed students to benefit the most from it. These results are not at odds with the possibility that with more training, fine-tuned materials, and the benefits of learning by doing active learning with blended technology may lead to significant improvements in mathematical competence. As we have shown, however, educational reform may entail sizeable costs in the short run. This implies that policy makers should monitor carefully the performance of the educational system during reforms and consider compensatory programs.

Study 4: "Improving math learning using technology: Experimental evidence from Chile"

Roberto Araya (Universidad de Chile)[4]

Elena Arias-Ortiz (Inter-American Development Bank)

Nicolas Bottan (Cornell University)

Julián Cristia (Inter-American Development Bank)

Background/Context: Latin American and Caribbean (LAC) countries fare poorly in international comparisons of learning assessments. Consequently, many countries in the region have been actively seeking innovative solutions that can improve students' learning, and have invested substantial resources to increase students' access to computers and connectivity at school. Unfortunately, emerging evidence suggests that programs that focus on expanding access to technology produce limited gains. On the other hand, recent rigorous evidence from China and India indicates that programs that provide clear guidance regarding how to use technological resources can generate substantial effects on student learning (Arias and Cristia, 2014). However, it is not clear whether these programs will also prove to be effective in LAC countries. Moreover, it is possible that effects may be even larger for technology in education programs that seek to promote student engagement by organizing school competitions (facilitated by technology) and collaborative learning.

Purpose/Objective/Research Question: This project evaluates whether technology in education programs that promote student engagement can improve Math learning. In particular, the project evaluates an innovative technology in education program, called Conecta Ideas, that has these features.

Setting: The intervention was implemented in 24 primary, public, low-performing schools in Santiago, Chile.

Population/Participants/Subjects: About 1,200 low socioeconomic students attending participated in the study.

Intervention/Program/Practice: The intervention aimed to improve Math learning among fourth graders. Focusing the intervention at this grade is motivated by the critical importance of Math at this stage and to take advantage of the data from the national fourth-grade standardized examination that the government of Chile implements yearly. Students participating in the program had two weekly 90-minute sessions at the computer lab. During these sessions, students were expected to solve exercises aligned with the curriculum that sought to promote conceptual understanding, problem-solving and mathematical fluency. Students also solved open-ended questions in which they were asked to provide explanations regarding how and why certain problems can be solved. These are questions that promote student reflection and metacognition. Additionally, teachers were expected to do one peer-review episode per session. During these episodes, students were asked to analyze and provide feedback to the

[4] Presenting author and contact author (email: roberto.araya.schulz@gmail.com).

resolution of a problem done by a classmate. Finally, bimonthly inter-school synchronized tournaments were arranged to foster motivation among students and teachers.

Research Design: The project experimentally evaluated the effects of Connect Ideas on Math and Language learning. To implement this randomized controlled trial, from the two fourth-grade sections in participating schools one was randomly assigned to the treatment group and the other one was assigned to the control group. Sections in the treatment group participated in the Conecta Ideas program while sections in the control group acted as a comparison group.

Program effects were estimated comparing average academic achievement of students in the treatment group with the average academic achievement of students in the control group. Because students were randomly assigned to treatment (at the section level), statistically significant differences in the average test scores across the two groups can be attributed to the effects of the program.

Data Collection and Analysis: Baseline data were collected in March 2017 to document that in fact the randomization produced similar treatment and control groups as well as to document the characteristics of the students participating in the project. Primary data was collected at endline in November 2017 to measure academic achievement. This internal test was designed and implemented by a local University. Moreover, effects on learning were assessed using data from the national fourth-grade standardized examination that is applied in all schools in Chile.

Findings/Results: Results indicate that the program increased Math test scores by about 0.30 standard deviations in the national standardized test. There were no effects on Language. Moreover, the effects measured in the internal test were 0.12 in Math scores (again, there were no statistically significant effects in Language).

Conclusions: The study suggests that technology in education programs that promote student engagement through tournaments and collaborative learning produce large improvements in Math learning. Future studies could investigate whether these positive results are replicated in other school contexts. In particular, they could investigate whether the large learning effects are due to the group dynamics and motivational mechanisms that the program promote through tournaments and collaborative learning.