IDRC CRDI
International Development Research Centre
Centre de recherches pour le développement international

APPLICATION FOR AN IDRC RESEARCH GRANT

NOTE: THIS FORM FOR USE ONLY AFTER PROJECT CONCEPT OR IDEA HAS BEEN ACCEPTED BY IDRC

Note: This document presents the proposal submitted to the International Development Research Center in October 2016 requesting funding to run an experimental evaluation of the Conecta Ideas program in Chile in 2017.

Title: "Improving Math learning using technology: Evaluation of "Conecta Ideas" in low SES schools in Chile"

Abstract

Latin American and Caribbean (LAC) countries fare poorly in international comparisons of learning assessments. Weak performance on these tests has been clearly linked to poor economic performance. 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 large effects on student learning. However, it is not clear whether these programs will also prove to be effective in LAC countries.

This project seeks to produce rigorous evidence on how to improve the quality of education using technology. The project will evaluate an innovative technology in education program called *Conecta Ideas*. Students participating in the program develop Math skills through regular practice with computers. The project is the result of the work of an inter-disciplinary team at the University of Chile. The team includes experts in the areas of education, technology and project management. The program has been already implemented for five years in 11 schools attended by low socio-economic status students in Chile. That is, the program has been designed to be implemented in low-performing schools so that it can be used as a tool to increase educational equity as well the overall academic performance of students.

OBJECTIVES:

Produce new knowledge based on rigorous evidence to inform effective policies regarding how information and communication technologies (ICTs) can be used to improve quality and equity of education in LAC schools.

The specific objectives are:

- Rigorously assess the learning effects (using a randomized controlled trial) and estimate the costs of an ICTs-based math teaching program in Chile (called Conecta Ideas).
- Determine success factors that need to be in place and provide clear protocols to ensure effective implementation and scale-up of similar programs in other low-income contexts.
- Seek to inform, influence and shape education policy to improve learning of math and other STEM-related subjects among low-income students in Chile and other LAC countries.

It is expected that as a by-product of the execution of the project important capabilities and practical experience will be developed among researchers and practitioners in Chile regarding the design and implementation of scientifically rigorous methodologies for assessing educational interventions. Additionally, the project coordinators will introduce mechanisms to foster the development of capabilities among other teams supported by IDRC in related projects as well as teams supported by the IDB in this area.

METHODOLOGY:

This methodological section describes five areas: (i) intervention description; (ii) theoretical framework; (iii) research design; (iv) gender and ethical aspects; (v) organization.

i. Intervention description

The intervention will be implemented in 20 primary, public schools attended by low socio-economic status students in Santiago, Chile. The participating schools will need to have a computer lab with at least 30 computers connected to the Internet. Each school will need to have two fourth grade sections with no tracking. The intervention will be implemented between April and November 2017.

The intervention will aim 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 will have two weekly 90-minute sessions at the computer lab. During the study we will monitor the time planned to be allocated to Math and actually allocated between the treatment and control classes to ensure that there are no major differences in this respect. During these sessions, students will solve 10 exercises aligned to the curriculum that will seek to promote conceptual understanding, problem solving and mathematical fluency. Students will also solve open-ended questions in which they will need to provide explanations regarding how and why certain problems can be solved. These are questions that promote student reflection and metacognition. We also plan to implement one peer-review episode per session. That is, during these episodes, students will be asked to analyze and provide feedback to the resolution of a problem done by a classmate. Finally, monthly inter-school synchronized tournaments will be arranged to foster motivation among students and teachers.

The project will provide a computer lab coordinator to facilitate the sessions at the computer lab. During the sessions regular teachers will support the general coordination of the sessions providing guidance to individual students and providing specific support to low-performing students. The software that will be used is a web-based environment that promotes whole class collaborative learning with peer support. Given that the platform records the activities performed by students, these data that can be analyzed using data mining techniques to track the intensity of the use of the platform and the coverage and balance of the curriculum that has effectively been covered.

The project will also provide training to lab coordinators to develop their capacity regarding technological and pedagogical aspects. The training will seek to provide practical knowledge regarding how to tackle common technical issues. Additionally, the training will seek to develop a clear understanding about effective pedagogical strategies to allow the adequate flow of the computer sessions. Teachers will also be trained to familiarize them with the software, explain them how they can use the information that the platform generates to diagnose problems and implement solutions and guide them regarding how they can take advantage of the sessions to improve learning and ensure that all students are progressing adequately.

A fundamental advantage of the project consists in providing automatic, real-time information about students' activities and academic progress. Lab coordinators, teachers, administrators and project managers can access the system online at any time to review the planned progress of the curriculum, as well as to check how much of the curriculum has been implemented. A real-time early warning system included in the platform will list students who are experiencing difficulties, so that the lab coordinator and the teacher will know which students need personal attention and for which specific exercises. The early warning system will also identify exercises that are proving difficult to the whole class, so that the lab coordinator can freeze the system and provide necessary clarifications. Teachers, administrators and project managers can also track the average number of exercises with immediate feedback categorized by curricular content and skill level, as well as the questions with open-ended answers.

During the implementation, technological and pedagogical support will be provided to lab coordinators and teachers to ensure that they are able to use the time effectively during the computer lab sessions. Regarding technological support, a central team will work on software-related issues taking advantage of the Internet connection to deal with problems and to install updates. Regarding pedagogical support, there will be regular visits to schools by a project coordinator to diagnose potential problems arising in the implementation and design and to implement solutions. Additionally, there will be regular meetings with lab coordinators, teachers and principals to discuss advances, challenges and next steps. Other technological tools, such as WhatsApp, will be used to allow easy and quick solution of potential problems.

The project will implement a number of activities to promote commitment and collaboration among all stakeholders. Superintendents of the educational districts participating in the project will review its design and the implementation. Subsequently, the principals and teachers in these schools will help implement and track student learning. Superintendents, principals, lab coordinators, and the project administrator will receive daily reports on the activities for each class, detailing the specific curricula content that has been covered. They will also receive weekly summaries to review the students' progress. Every two months they will participate in meetings to review the students' progress. The active participation of district superintendents and principals will facilitate the future implementation of this strategy on a larger scale.

ii. Theoretical framework

The theoretical framework is based on the notion that the learning of evolutionary secondary knowledge (academic knowledge such as fractions) depends on practice. This is very different from evolutionary primary knowledge (Geary, 2007), such as learning to walk or talk which can be based on autonomous exploration. On the other hand, effective methodologies require immediate feedback. Furthermore, evolutionary secondary knowledge is not as engaging as evolutionary primary knowledge. However, play and social games facilitate engagement, collaboration, and learning math contents (Araya et al., 2011, 2016). Another critical issue is that teachers and administrators do not have to lose the control of the process. Under the Conecta Ideas program, teachers and administrators can have students in their classes completing online exercises and playing in teams, while at the same time they can track learning and engagement of the students in every class. Therefore, teachers and administrators can adapt activities according to ongoing engagement and student learning.

iii. Research design

The project will seek to assess rigorously the effects of the Connect Ideas program by implementing a randomized controlled trial. We will use this evaluation design because it is well recognized that it can generate unbiased estimates of program effects. This is why researchers and policy-makers are increasingly promoting the use of this technique to estimate program effects.

To implement this randomized controlled trial, from the two fourth-grade sections in participating schools one will be randomly assigned to the treatment group and the other one will be assigned to the control group. Sections in the treatment group will participate in the Conecta Ideas program while sections in the control group will act as a comparison group. Data will be collected at baseline (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. Data will be collected at endline (in November 2017) to measure the effects of the program.

Program effects will be estimated comparing average academic achievement of students in the treatment group with the average academic achievement of students in the control group. Because students will be randomly assigned into treatment, statistically significant differences in the average test scores across the two groups can be attributed to the effects of the program. The main analysis will include test data collected as part of the evaluation. Still, additional results will be estimated using the national fourth-grade standardized examination.

Logs of regular activity in the platform will be recorded in the cloud. These data will include the time in which each exercise was completed by each student, the corresponding score, information on whether the student received immediate automatic feedback, whether they received help via chat from a remote teacher, whether they helped a peer, whether they received help from a peer, whether they graded the support they received, whether the exercise was part of a tournament, the answers that they wrote to open-ended questions, and the answers to the surveys. Moreover, apps running on smartphones and tablets will help observers register classroom practice. This will be done once a month for every class. All information will be anonymized for reports and publications in order to ensure privacy and confidentiality.

These computer logs will be analyzed using data mining algorithms to provide a deeper understanding of the underlying causes explaining the documented impacts. This analysis will investigate the number of activities performed by students in the treatment group, the curriculum areas covered, and the performance of students in solving these exercises. Additionally, the analysis will explore how time was used during the sessions. For example, how much time students spend in solving exercises, when they start solving them and when they finish. Additional analysis will document whether content areas emphasized in the intervention showed larger differences in average achievement between students in the treatment and control groups. Other educational data mining tools will also be used, such as machine learning algorithms for text mining the students' answers to open-ended questions, as well as the questions themselves. Statistical pattern recognition will be performed to detect and recognize patterns in teacher practices registered by data gathering tools for class observation.

To ensure the independence of the evaluation, there will be a clear separation of areas of responsibility in the teams collaborating in the study. On one hand, the team from the Universidad de Chile will be in charge of the design and implementation of the intervention. On the other hand, the team from the IDB will be in charge of the evaluation of the intervention. Consequently, the data collection and analysis will be supervised the IDB team and there will be clear procedures to be followed to ensure the independence of the evaluation. This institutional arrangement has already been implemented with success in the evaluation of the One Laptop per Child program in Peru. In that case, the Minister of Education of Peru designed and implemented the evaluation and the IDB team was in charge of the evaluation. The evaluation reports published showed that the intervention did not generate statistically significant effects on Math or Language. The publication of documents reporting a lack of effects of the intervention attests the capacity of this institutional arrangement to ensure the objectivity and independence of the evaluation. Finally, we plan to collect data to construct objective indicators of fidelity of implementation to document this important aspect.

A recent study by Ginsburg and Smith (2016) points to the importance of not measuring the effects during the first year of implementation of a program because of the possibility of low fidelity of implementation. This challenge is partially tackled in the current proposal because the Conecta Ideas program has been implemented for a number of years in Chile, and hence, there has been important learning-by-doing developed by the implementation team. However, it is true that the program will be implemented in a set of new schools in which principals and teachers will be working with the program for the first time. Still, we consider that the program should have a high fidelity of implementation because of critical role that session coordinators play in the program, the strong training and support that they receive and the specialized nature of their work. Moreover, fidelity of implementation in the Conecta Ideas program should be less of an issue compared to other programs because the access to logs documenting the number and type of exercises solved by beneficiary students greatly facilitate the monitoring of the implementation protocol.

Ginsburg and Smith (2016) also emphasize the importance of using assessments that are "fair" to both the treatment and control groups. That is, it is important that the assessment does not focus on areas or items that are emphasized by the treatment group. In particular, the authors of this study suggest avoiding the use of assessments designed by the implementation team. Our proposal to evaluate the Conecta Ideas program incorporates this suggestion as we plan to obtain the test scores of the students participating in the study from the national standardized examination taken by all four graders in Chile every year. This test is designed and administered under the supervision of the Ministry of Education of Chile.

For policy purposes, the estimation of the costs of a program is as important as the estimation of its benefits. This is because all governments have to allocate limited educational budgets to different activities. And this is particularly relevant in the case of developing countries that typically have to face multiple face with limited resources. Hence, having precise estimates of costs and benefits of alternative programs allow allocating limited public funds to those options with the highest benefit per dollar spent. In this project, we plan to estimate costs following standard procedures and practices documented in the relevant literature. Important information regarding costing educational interventions is included in the studies by Dhaliwal et al. (2011), Levin and McEwan (2000) and McEwan (2012). Moreover, Berlinski et al. (2011) have implemented specific analysis of cost estimates for the case of educational programs that use technological resources. Additionally, Arias

Ortiz and Cristia (2014) review the costs of different educational programs that use technological resources and discuss the how these costs may vary across programs and contexts. Finally, ongoing work for the 2017 flagship report of the IDB involves the estimation of costs of different educational interventions. The knowledge generated during the development of these cost analysis will be also used to estimate the cost of implementing the Conecta Ideas program.

In general, the literature and good practices on cost estimation suggest a number of guiding principles. First, all costs should be expressed on a common currency. This involves deflating costs that are incurred in different time periods to take into account inflation. Moreover, it also involves adjusting costs in different time periods to take into account the opportunity cost of economic resources (i.e. adjusting costs using a discount factor). Second, all direct costs needed for the provision should be included. In the case of indirect costs (e.g. management services that are allocated to different projects) standard procedures should be followed to allocate a portion of these costs to the project in consideration. Third, costs should reflect the opportunity cost of the necessary resources. For example, if education is provided in a building owned by the government, even though there will be no financial payments for the use of the infrastructure, the opportunity cost of the use of the building should be computed. In practice, these opportunities costs are approximated using as much as possible information from market prices (e.g. rental costs of similar facilities). Fourth, the cost of certain resources that will be used only during a fraction of the duration of the intervention, such as computers, should be allocated to the project using standard procedures. Overall, the costing exercise should seek to follow objective procedures and avoid to the extent possible the use of ad hoc assumptions. This overall principle is especially relevant for the cost components that represent a large share of the budget because, in these cases, different assumptions can induce important differences in the total cost estimates.

During the implementation of the project, a parallel qualitative evaluation will be carried out to explore the success factors of the program. Qualitative evaluations are complementary to quantitative studies and seek to provide deeper information about critical aspects such as the cultural context, the pedagogical process and class dynamics. It has been shown that exploiting the comparative advantages of qualitative and quantitative evaluations can lead to more comprehensive analyses and richer conclusions. The main objectives of the qualitative evaluation of the Conecta Ideas program are the following: i) to collect information about the beliefs, motivations and attitudes of students, teachers, principals and lab coordinators regarding the program; ii) to analyze how the use of technology affects the pedagogical process and classroom dynamics focusing in particular on the interactions among students and between students and teachers; and iii) to determine how contextual factors at the classroom, school and community level may affect the successful implementation of the program. The final goal is the analysis of these aspects will be used to provide a series of specific recommendations for the design of the program and a list of critical factors for the successful implementation of the program.

In terms of methodology, the qualitative evaluation will be based on the analysis of at least three sources of information: i) project documentation; ii) semi-structured interviews for students and teachers (10-15 interviews) and iii) classroom observations (10-15 classes). The interviews and the classroom observation will take place at two moments in time during the implementation in order to analyze changes over time. The design and the implementation of the qualitative analysis will be executed in close coordination with the quantitative analysis in order to ensure strong complementary between the two evaluations. Finally, the qualitative evaluation will be conducted by researchers with specialized expertise in this area that will be selected based on their educational background, experience in similar projects, relevant academic publications and demonstration of specific skills (e.g. use of specialized software for qualitative evaluations such as Nvivo or Atlas.ti).

(iv) Gender and ethical aspects

It has been documented that girls tend to underperform in Math compared with similar aged boys in LAC countries. It has also been documented that women tend to receive lower wage rates in the labor market. These two empirical facts may be at least partially casually linked given that women are underrepresented in occupations that require strong Math skills and that are well rewarded in the labor market (e.g. Engineering, Computer Science, Finance and Science). Consequently, fostering Math skills among women can be a promising policy instrument to achieve the goal of reducing gender pay gaps.

In this project, we will explore how the Conecta Ideas program may differentially affect learning of boys and girls. To start with, we will estimate the effects of the program on Math achievement separately by gender. Moreover, we will exploit the computer logs to investigate whether potential differences in effects may be linked to differences in the intensity of the use of the platform. Additionally, we will also analyze whether differences in computer use and effects may differ across different Math areas. We will also analyze whether certain factors (e.g. limited practice in specific areas) may be more prevalent for male or female students and the potential consequences of these factors on explaining differences in academic achievement. This exploratory analysis, that is based on documenting certain correlations, will not be conclusive but could put forward certain hypotheses for future work. Overall, we expect that these results can illuminate policy decisions aimed at reducing gender pay gaps through reducing gaps in Math skills.

The project will also incorporate ethical considerations. To start with, the project will provide clear communications about the structure and activities of the intervention to all relevant stakeholders. Moreover, we will seek **w**ritten consents from students' parents or legal guardians as well as from teachers. Additionally, the main data used in the analysis will be anonymized as a further precaution to ensure the confidentiality of the data and to protect the privacy of the individuals participating in the study. Finally, the project proposal, the letters of consent and the letters of agreements of the project with the schools' principals will be reviewed by the Center of Studies on Applied Ethics in the Philosophy and Humanities Department of the Universidad de Chile. This Center will produce a review report following the standard procedures regulated by the National Commission on Scientific and Technological Research in Chile (Comisión Nacional de Investigación Científica y Tecnológica, CONICYT).

(v) Organization

This project involves the collaboration of the Universidad de Chile and the Inter-American Development Bank. In particular, the project will be coordinated by Roberto Araya from the Center of Advanced Research in Education at the Universidad de Chile. This Center is composed of experts in different areas relevant for the design and implementation of educational projects including pedagogy, technology and project management. The Center will be in charge of implementing the program in Santiago, Chile. Regarding the participation of the Inter-American Development Bank, Elena Arias Ortiz from the Education Division and Julian Cristia from the Research Department will also collaborate in the project. These researchers from the Inter-American Development Bank will participate in the research design, production of protocols of intervention and data collection, data analysis and policy dissemination.

PROJECT SCHEDULE:

November 30, 2016: Hire project coordinator

December 15, 2016: Recruit schools

January 6, 2016: Produce implementation protocol

January 20, 2017: Hire lab coordinators

January 31, 2017: Train teachers and lab coordinators

February 28, 2017: Produce the software test version

March 31, 2017: Install software

March 31, 2017: Apply baseline test

March 31, 2017: Apply first set of interviews and classroom observations

April 1 to July 14, 2017: Implement the program during the first semester

July 7, 2017: Apply mid-term test

August 31, 2017: Produce mid-term analysis

August 1 to November 30, 2017: Implement the program during the second semester

November 30, 2017: Apply first second set of interviews and classroom observations

November 18, 2017: Apply final test

April 30, 2018: Produce preliminary report using data collected by the project

May 30, 2018: Preliminary report for the qualitative evaluation

October 31, 2018: Access to test data from national standardized examination administered by the Ministry of Education

February 28, 2019: Produce the working paper