ICT Supported Learning Rises Math Achievement in Low Socio Economic Status Schools

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Abstract. Sustained improvement in student achievement on national standardized tests for low socio economic status (SES) districts is critical for reducing gaps in educational inequality. We report the results of 3 years of implementation of an ICT web-based learning environment in all 11 public schools of a low SES urban district in Chile. This includes 43 fourth grade classes and 1,355 students. This is a Computer Aided Instruction program that promotes whole class collaborative learning with peer support. Effect size on the national standardized fourth grade math test is 0.33, which is three times the national improvement level over the same period and five times the improvement made by a neighboring district with a similar population. On the other hand, the same students did not make any improvements on the national standardized language test. Since each class was taught by the same teacher, only without ICT, we can therefore discount the teacher effect.

Keywords: Computer aided instruction · Web-based learning · Effect sizes

1 Introduction

Sustained improvement in student achievement for low SES schools is critical for reducing gaps in educational inequality. This enormous challenge has several components. First, there is the difficulty of reliably measuring student achievement [7]. This requires being able to conduct annual national standardized tests. Furthermore, it is necessary to do large-scale, randomized control experiments. In the absence of such randomized trials, it is necessary to do non-experimental studies using statistical controls that include the relevant factors with which students are sorted by teachers and schools [13]. Next there is the difficulty of obtaining effects of an interesting size. Large-scale studies of the effect on student achievement for different factors do not reveal huge impacts. For example, factors such as the type of institution that educate the teachers [10], teacher certification [12], teacher professional development [13], change of teaching practices [6, 8, 14], textbooks [3], leadership strategies [17], use of computers [9, 22–24], and use of calculators [20], show impacts of a modest size or no

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effect at all. In other cases, it is not clear how to change practices [6]. Moreover, most of these studies use pre- and post-tests designed or selected by the researchers and they are not necessarily aligned to the national standards, unlike national standardized tests.

Impact studies are much scarcer in developing countries. Firstly, there is a lack of resources for funding research projects, particularly if the study lasts several years. Secondly, resources for implementing Computer Aided Instruction (CAI) programs are very scarce. This is due in part to computer labs being less widely available, as well as there being less technical support for computer labs. There is also much less access to internet, narrower band width, as well as more unstable and unreliable internet services. Large-scale studies of the impact of ICT on student achievement in low SES schools in developing countries are even more difficult to find. On the other hand, there is extensive empirical research under laboratory conditions [11, 18], which shows that practice with feedback makes a big difference.

2 Methods

In this study we report 3 years using Supplemental CAI [5] on low SES schools. Teachers and lab coordinators track the students' progress with their smartphones. A real time early alert system lists students who are having more difficulties. The platform is designed to drive the progression of the entire class as a whole, and not to leave students alone by themselves. It has facilities to promote the cooperation and support of students that are ahead of their peers. We present evidence of 43 fourth grades classes from every urban public school in Lo Prado, a low SES municipality in Chile. This includes 16 fourth grade classes from 11 schools that used the CAI model in 2011, 16 classes from the same 11 schools that used the CAI during 2012, and 11 classes from 8 schools among the same 11 schools that used the CAI during 2013. This is a total of 1,355 fourth grade students which completed a total of 967,830 exercises on the CAI platform. Every year, fourth grade students have to take a national standardized test in mathematics, and another national standardized test in language. These tests are called the Mathematics SIMCE and the Language SIMCE, respectively. We will use the SIMCE test results to measure impact. Firstly, we compare yearly gains on the national standardized mathematics test. We define the yearly gain for each class as the difference between the score in a given year and the 2010 score for each school. The government publishes the scores for each school, but not the scores for individual students. Furthermore, if there are two or more fourth grade classes in a school, the government sends the score for each class to the corresponding school. However, not all of those class scores were obtained for this study. We use the class score when available, and the school score otherwise. As a control, we use the entire country, as well as a neighboring district with the same SES. Secondly, we compare the yearly gains on the mathematics test with the yearly gains on the language test in the same classes. In each class, both subjects are taught by the same teacher. Therefore, by comparing scores we can analyze the impact of the teacher and ultimately calculate whether the improvement was independent of the teacher.

3 Results

The yearly gains on the national standardized mathematics test for municipal schools in the municipality of Lo Prado was 0.33 standard deviations, which is greater (for a 99 % confidence level) than the 0.11 standard deviations witnessed by schools across the rest of the country, and the 0.07 standard deviations in the neighboring municipality of Pudahuel. These two municipalities are very similar. In fact, they used to be the same municipality until a few years ago and they have a similar SES [1].

It is important to note that attrition was very low. For example, in 2013 in Lo Prado, from the 332 students doing exercises at the beginning of the year, only 20 students did not finish the year at the school (i.e. 6.2 %). 11 of them (3.4 %) had scored below the average on the CAI platform and 9 of them (2.8 %) had scored above the average. In other words, attrition is low and it is equally distributed between high and low performing students. It is possible that the increase in the yearly gains on the mathematics test is due mainly to the contribution of the teachers and/or schools. Since in all the classes the teacher teaches all subjects, if the effect is due to specific characteristics of the teacher then one would expect that classes with an increase in yearly gains on the mathematics test would also see an increase on the language test. Conversely, if there is no clear relation in the increase or decrease across subjects, then the increase in mathematics is not just caused by the teacher. In Lo Prado, yearly gains on the mathematics test was 0.33 standard deviations, which is higher (99.9 % confidence level) than the yearly gains on the language test, which was −0.02 (a decrease). It is important to note that the Supplemental CAI model was only implemented for mathematics. In language, they implemented a different strategy.

It is also important to study the effect of the lab teacher in charge of the laboratory. Four lab coordinators took charge of the lab in the 11 schools, moving from one to another to assist classes during the sessions. We will look at the two lab coordinators with most classes in Lo Prado. The yearly gains on the mathematics test achieved by one lab teacher was 0.384 standard deviations, which corresponds to 5 classes. The increase achieved by the other lab teacher was 0.382 standard deviations, corresponding to 14 classes. They are similar for a 99 % confidence level.

How different is the impact obtained in Lo Prado municipal schools from the ones analyzed in the literature? For example, reference [22] reviewed 38 studies of the impact of Supplemental CAI programs, but only 15 of these studies used randomized or quasi-experimental designs. The median effect size was +0.19. In our implementation in the district of Lo Prado, the yearly gain on the SIMCE math test was +0.33. If we consider the neighbor municipality Pudahuel as control we get a net effect size of $0.33 - 0.07 = 0.26$. However, when using the assessment tests from the CAI platform between the beginning of the year and the end of the year, the improvement was +0.63 standard deviations. This effect is almost twice the yearly gain on the SIMCE math test. On the other hand, we have seen that it is reasonable to use the urban schools of the neighboring district of Pudahuel as a control group. They have a yearly gain on the SIMCE math test of +0.07. If we assume that the same relation holds true in Pudahuel as it did in Lo Prado, for the conversion between yearly SIMCE gain to the difference in the CAI test, then we can estimate the difference in the assessment test used in CAI for schools in the district of Pudahuel. If they would have taken the same assessment tests as those used with the CAI platform, then they would have obtained an effect size of +0.14. Both Lo Prado and Pudahuel use the "Ley Subvención Escolar Preferencial (SEP)" (the Law for Preferential School Subsidies) to fund its projects. SEP is a special government subsidy for schools with low SES students. All municipalities have access to a similar amount of funding per student and decide how to allocate its funding. Most of them use it for a blend of teacher training and support from external companies and universities. We can therefore use Pudahuel as a typical control group. After discounting the control group, the effect size for Lo Prado is 0.63 − 0.14 = +0.49 standard deviations. This effect is similar to the effect size of +0.39 obtained in [2] in India with a CAI program, but much higher than the effect of +0.16 obtained in [19] for rural school in China, and the effect size of +0.14 obtained in migrant schools in China [15, 16]. It is also higher than the median effect size of 0.19 found in [22].

The larger effect in Lo Prado compared to the other studies can be explained by the fact that in the case of Lo Prado, students attended one or two sessions per week that lasted 80 min (80 % of the time) and 40 min (20 % of the time), whereas in the study [22], most students attended the lab once a week for 30 min. Moreover, the yearly gains on the national standardized mathematics test by the classes from Lo Prado are correlated to the number of exercises with immediate feedback completed between the end of March and early October (just before the national test). There is an increase of 0.18 standards deviations on the math SIMCE test for every 100 extra exercises completed online per student (p-value of 0.006705, $R^2 = 0.2205$).

From each of the fourth grade classes in the 8 schools in Lo Prado using CAI in 2014, we took a sample of traditional material from 5 students. These were 5 notebooks, 5 worksheets and 5 other paper-based materials per class. With the CAI platform in Lo Prado, each student completed 10.2 exercises with feedback per session, whereas they only completed 3.2 exercises with feedback per session using traditional paper-based materials. The difference is huge. Only 50.9 % of the exercises assigned (copied by hand or printed on the worksheets) are completed by the students, with little feedback given on those that are completed. Only 3.8 % of the exercises that were assigned are completed and received feedback. This can explain why learning is faster [4] with a CAI model than in a regular classroom without computers.

It is also very important to compute separately the impact of CAI on strong and weak students. For each class, we define weak students as those who score below the class median for the test at the beginning of the year (March and April). The remaining students are classified as strong. Very similar tests were taken at the end of each year (October and November). The average improvement made by weak students is 1.08 standard deviations of the initial performance by the entire population, whereas the improvement by the strong students is 0.17 standard deviations. The average improvement for all students is therefore 0.63 standard deviations. Thus, the average improvement made by the weak students is 6.3 times more than the average improvement made by the strong students. These improvements are statistically significant for a 99.9 confidence level.

4 Conclusions

A critical question is: How does the use of technology in education can help increase student learning? [21] We have reviewed the data from three years of implementing the Supplemental CAI strategy. Students practice twice a week in computer labs throughout the school year. Each year we take the average score by the whole class on a national standardized test and compare it with the score by each school from the year before the implementation of the program. We have seen that the CAI program has produced a sustained impact. The effect size reached for a low SES district on the national standardized fourth grade math test is 0.33. This is much higher than the average improvement by the rest of the country. In fact, it is three times more than the improvement made by the rest of the country over the same period, and five times more than the improvement made by a neighboring district with a similar population. We have seen that a potential cause of the results is the intensity of practice. On average, classes that practice more achieve greater improvements. Another critical factor is that the students receive timely feedback. Students do a lot of exercises on paper but they receive very little immediate feedback. Using CAI, they receive three times as much feedback per session than they receive in a regular class. Improving student achievement is not easy. Several studies that have examined factors such as teacher education, certification, and professional development have shown little impact. However, the results reported from this low SES district are very promising. ICT supported learning can be very effective if properly implemented.

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