Impact of a blended ICT adoption model on Chilean vulnerable schools correlates with amount of on online practice

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Abstract. The impact of a blended ICT adoption model in 15 fourth grade classes from 11 vulnerable Chilean schools is analyzed. In this model, twice a week students attend a computer lab where the lab teacher and the class teacher select and assign on line math exercises. The platform contains approximately 2,000 exercises, but it is constantly growing with exercises introduced by teachers. During sessions the system continuously tracks students and detects students that are falling behind, allowing teachers to provide real time support and drive the progression of the entire class as a whole. Students that finish early and with good performances are assigned as part of the support team for the rest of the session. After a year of implementation, the national assessment test SIMCE math on these classes raised 0.38 standard deviations. This is more than three times the historic national improvement in 2011. The statistical analysis shows that the improvement was independent of teacher effects, and correlates with the average number of on line exercises done per student in that year.

Keywords: adoption model, ICT impact, national assessment tests, educational data mining, at risks students

1 Introduction

We study a blended Information Computer Technology (ICT) adoption model focused on ensuring intensive student practice and real time support from teacher and more advanced peers. We implemented this ICT model on several low socioeconomic status Chilean schools with high proportion of at risk students. According to a recent UN report [11], Chilean gross national income (GNI) per capita is 14,987 in 2005 PPP $, Chilean Human Development Index is the highest in Latin America and ranks 40 in the world. Even though gross national income per capita has had an important average annual growth of 3.8 from 1990 to 2012, there is huge school segregation by socioeconomic status in Chile. There is also a big educational inequality measured as

interschool standard deviations on a UNESCO math and language tests for third and sixth graders [14], [1], though the educational inequality is generally lower than in other Latin American countries. For example, in the UNESCO math test for third graders, interschool standard deviation was 1.97 the standard deviation obtained if students were randomly assigned, which is one of the lowest ratio of the studied countries. The educational inequality is more pronounced on the urban sector than in the rural sector. According to the last OECD PISA-2009 assessment [16], [17], science and reading performances have been improving and the performance gap in reading between high and low socioeconomic status students has being reducing. From the first UNESCO study [12] to the second UNESCO study [14], the relative position in Latin America of the math performance of Chilean third graders improved. Also the Chilean national math assessment test for fourth graders (SIMCE) shows in 2011 a significant improvement (0.12 standard deviations) and the performance gap has also been reducing (0.22 standard deviations). According to UN [11], fixed broadband internet subscription was 10.5 per 100 people in 2010 in Chile. This is one of the highest subscription rates in Latin America together with Uruguay and Mexico. Fixed and mobile telephone subscribers were 136.2 per 100 people in 2010. In schools, 90.2% of students have computers to use with access to internet [13].
Adoption of ICT generates several benefits in education [18], [19], but it also poses several challenges particularly in vulnerable schools. According to our field experience in vulnerable schools there is a weak ICT infrastructure, poor equipment maintenance, poorly prepared technical support personnel, high frequency of electric supply problems, and instable connection to internet. All of the difficulties were present on the schools where the model was implemented. Besides school infrastructure, there is a much weaker ICT infrastructure at students' homes, less availability of internet access and much weaker access to technical support. Other important difficulties in these schools are a higher proportion of at-risk or behind-grade-level students, higher percentage of students that are struggling with core math concepts, and lower attendance rates than in other schools. Additionally, students' families have less cultural capital, and therefore students are harder to teach. Teacher quality is also generally lower in these schools, since better teachers once detected they receive offers to migrate to higher socioeconomic status schools. All of these conditions pose a much higher challenge in the introduction of ICT and the possibility to have a positive impact.

2 Method

One of the main goals of the implemented model was to provide technological and human resources to increase the amount of student practice on mathematics and also to provide real time feedback for all students, and particularly for struggling students. There is abundant literature reporting the positive effect of practice in ideal laboratory conditions. There is the positive effect on memorization [6], in long term retention [7], in understanding when compared with spending time building concept maps or only studying [3], and the positive effect of practice throughout several sessions [8].

Another important aspect is feedback. There are different types of feedback: immediate versus delayed, simple positive feedback if the answer is correct or negative feedback if it is incorrect, or deeper feedback with suggestions of alternative solutions, feedback aimed at increasing student effort, etc. In a review of dozens of studies [2] concluded that the positive feedback for right answers is better than negative, and that feedback given by video, audio or computer systems is the most effective. There is also evidence of the positive effect of accumulated practice in solving mathematical problems [4]. More practice produces more learning, particularly if practice is mixed with previously learned knowledge. However there is lack of studies of impact outside of laboratory conditions [9], and particularly in low socioeconomic schools. There are several important challenges to implement a strategy based on intensive practice. One of them is motivation. There is the need to spark engagement with math problems throughout the whole year. Moreover to improve the performance of a complete class it is necessary to motivate struggling students to do intensive practice. At the core of the blended adoption model there is an early alert system. At every moment, the system lists students who are having more difficulties. In this way the teachers know in real time which students need personal attention and in what specific exercise. The early alert system also detects if there are exercises that are producing high difficulty to the whole class. This way the teachers can freeze the system and explain the required concepts. The platform is designed to drive the progression of the entire class as a whole, and not to leave students alone. It has facilities to promote the cooperation and support of students that are ahead of their peers. Students that finish early and with good performances can be assigned as part of the support team for the session. The system assigns them to help peers with difficulties. At the same time, students that are being assisted by peers assess the quality of each support event. This information helps the teachers to monitor the quality of the support and the need to teach support strategies to advanced students.

The model was implemented in 11 schools. The first year the system was implemented in the second half of the year, but most of the time was dedicated to solve infrastructure problems. In the second year (2011) the system was running in more normal conditions. All of the 469 students from the 15 fourth grade classes of the 11 municipal schools from the Lo Prado municipality were using the system. Lo Prado is a low socioeconomic district in Santiago. During the year 2011, from end of March to early October the students did 203,782 on line math exercises. After mid-October students did more exercises but they were done after the National test SIMCE, and therefore they will not be considered in the analysis. Around 20% of the exercises were assessment exercises and the rest were exercise with feedback. For every exercise done by a student, the platform records the response time as well as the performance. In the case of an assessment exercise, the system records if the student answered correctly or not, and in the case of exercises with feedback it records the number of attempts to achieve the correct answer.

3 Results

According to What Work Clearinghouse standards of the U.S. Department of Education, evidence of effectiveness [10] of educational interventions is classified into three levels: low, moderate and strong. Evidence is low when it is based only on expert opinion, which is derived from strong findings or from theories in related areas and/or expert opinion. Evidence is rated as moderate when they are made with high internal validity studies (studies whose designs support causal conclusions) but moderate external validity (studies that include a sufficiently broad range of participants to be generalizable), or vice versa, but not both validities simultaneously. At this level, belong the typical quasi-experimental studies (i.e., the control and experimental groups were not randomly assigned) that show the effectiveness of a program, or studies with small samples or groups that are not equivalent at the pretest, or correlational research with strong statistical controls to avoid selection bias or assessments that meet the Standards for Educational and Psychology Testing but the samples are not adequately representative of the population. Evidence is strong if the studies have high internal and external validity. These designs include randomly controlled trials, multisite, large scale, and no contradictory evidence.

We make two types of analysis. First we compare the SIMCE math gains of all the schools of the Lo Prado district with the result of the whole country. We also compare the Lo Prado SIMCE math gains with the results of the urban schools of a very similar neighbor district of the same socioeconomic level. Second, we compare the Lo Prado SIMCE math gains with the Lo Prado SIMCE language gains and SIMCE science gains in the same classes. Given that in each class all subjects are taught by the same teacher, this comparison aloud as to explore the teacher effect and eventually compute if the improvement obtained is independent of the teacher. Therefore, the study reported here could be classified as quasi experimental at best, and then the evidence can be classified as moderate.

One difficulty of analysis is that the SIMCEs scores are not published by student. We only have the average score of each class and the standard deviation of the country. For this reason, in what follows we use the variation of SIMCE for classes. We define the SIMCE variation for a class in a given school as the difference between the SIMCE 2011 score obtained by the class with the SIMCE 2010 average of all classes of the school. It is important to note that the students are different, since they belong to different generations. We are comparing the 2011 score of a class with the average score of the school in the previous year.

The increase of SIMCE math for the municipal schools of the Lo Prado municipality was of 16.27 points, which is greater than the variation of all schools in the country. This increase is obtained from the simple average of the SIMCE math scores of the schools. However, some schools have fewer students, so the simple average of the schools is not the most representative. Weighting proportional to the number of tested students in each course, the variation in SIMCE for math was 19.15 points. This increase is more than three times the historical rise of the country SIMCE math that was 6 points [5], and it is much higher than the increase of 8 points in SIMCE math in the schools with similar socioeconomic classification as 10 of the 11 schools analyzed.

This improvement is an in increase in 0.38 standard deviations. To test if the average improvement of the 15 classes of Lo Prado is higher than the 6 points of the average of the country student's improvements and the 8 points of the average of the country at risk student's improvements, we consider the fact that we have the standard deviation σ of the student performance in the country. From that information we can compute the standard deviation of the average of the score improvement of the 392 students that took the SIMCE test. The standard deviation σ of the student performance does not change from one year to another and σ=50. Assuming independence of the performance between students, the variance of the performance of each class i equals $\frac{\sigma^2}{n_i}$ where n_i is the number of students on the class i, and similarly the variance of the average performance of the school s(i) where the class i belongs to is equals $\frac{\sigma^2}{n_{s(i)}}$, where $n_{s(i)}$ is the number of students on fourth grade at the school s(i). The difference D_i between the score of the class i and the school average on the previous year has a variance equal to $\frac{\sigma^2}{n_i} + \frac{\sigma^2}{n_{s(i)}} = \frac{\sigma^2(n_i+n_{s(i)})}{n_i n_{s(i)}}$. Thus the weighted average score D= $\frac{1}{n}\sum_{i=1}^{k} n_i D_i$ of all the k=15 classes of Lo Prado has a variance Var(D)= $\frac{\sigma^2}{n^2}\sum_{i=1}^{k}\frac{n_i(n_i+n_{s(i)})}{n_{s(i)}}$, where n is the total amount of students in the k classes. The null hypothesis is H_0: $\mu = \mu_0$, where the observed mean of D is 19.15 and μ_0=8 is the mean improvement of all the at risk schools in the country (or μ_0= 6 is the mean improvement of all the students of the country). Since Var(D) = 11.1622, the cohen´s d = 3.3719, and then p=0.00074665 for μ_0 = 8. Thus the improvement obtained in Lo Prado is statistically significant. The difference between the country improvement and the average improvement of the 392 students from Lo Prado is statistically significant with a two tailed p-value < 0.0005 and the difference between the improvement of all the country at risk students and the Lo Prado students improvement is statistically significant with a two tailed p-value=0.00074665.

It is very instructive to compare the results of the schools belonging to the municipality of Pudahuel. This is a neighbor municipality and that years ago were both part of a single municipality. In Pudahuel we only consider urban schools. They are similar to those of Lo Prado which all are urban schools. Figure 1 shows the distribution of vulnerability of municipal schools in Lo Prado and the urban municipal schools of Pudahuel. The average of the 11 school´s proportions of at risk students in Lo Prado is 0.80 whereas the average of the 14 school´s proportions of at risk students in Pudahuel is 0.77. The t-test of two sample sizes and unequal variance does not reject that they have different proportions (two tailed p-value= 0.36). In addition, 10 of the 11 schools of Lo Prado are classified as “medium low” socioeconomic status (SES) by the Ministry of Education, and the remaining school is classified as "medium", which is quite similar to what occurs in Pudahuel, where 12 of the 14 schools are classified as "medium low" and the other two as "medium".

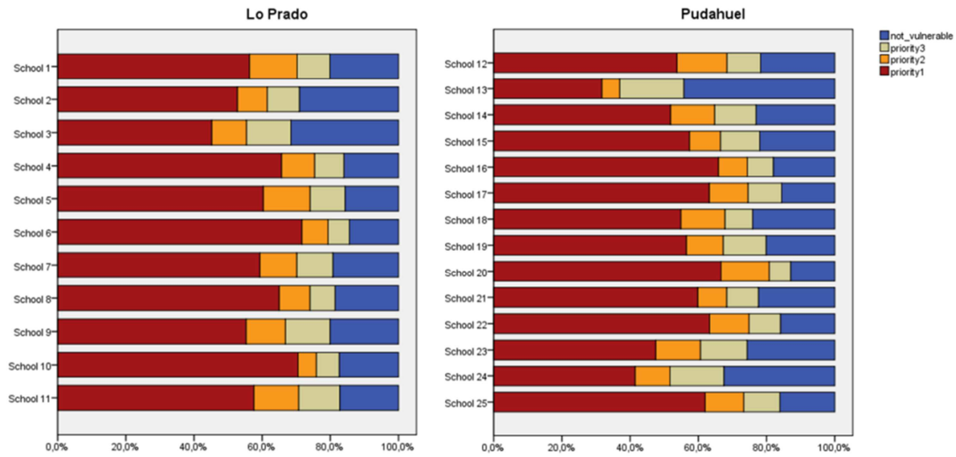

Figure 1: Proportion of at risk students in the schools of Lo Prado and Pudahuel.

In Lo Prado district the increase of SIMCE math schools was 19.15, corresponding to 392 students that took the SIMCE, whereas in Pudahuel the increase was 12.5, corresponding to 790 students. Using again the fact that the standard deviation of the average score improvement of all students on both municipalities can be computed from the standard deviation of student scores, the difference between the average scores however has a p-value = 0.064 unilateral.

There is a possibility that the increase in math SIMCE is due mainly to the contribution of 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 increase in SIMCE math then would also have increase in SIMCE language and SIMCE science. Conversely, if there is no clear relation in the increase or decrease across subjects then the increase in mathematics is not only effect of the teacher. In Lo Prado the increase in SIMCE math was 19.15, which is much greater than the increase in SIMCE science SIMCE which was 9.66 (0.19 standard deviations) and the increase in SIMCE language that was -3.35 (0.07 standard deviations). It is important to note that the online exercise strategy was implemented only in mathematics. In language three year ago the municipality implemented a different strategy not using ICT and more recently it implemented another strategy in science but also not using ICT. Furthermore, we tested the statistical independence of changes or if there is any correlation in the 15 classes between the behavior of SIMCE math with SIMCE language and SIMCE science. As shown in Table 1, the Pearson correlation test showed positive and statistically significant correlations between the change in math and language, and between language and science, but not between mathematics and science. These tests ruled out that the possibility that the rise in SIMCE math is due entirely to teacher effect.

Table 1. Correlations between language, math and science variations.

		language_variation	math_variation	science_variation
language_variation	Pearson Correlation	1	,651**	,777**
	Sig. (2-tailed)		,009	,001
	N	15	15	14
math_variation	Pearson Correlation	,651**	1	,334
	Sig. (2-tailed)	,009		,243
	N	15	15	14
science_variation	Pearson Correlation	,777**	,334	1
	Sig. (2-tailed)	,001	,243	
	N	14	14	14

**. Correlation is significant at the 0.01 level (2-tailed).

It is also important to see the effect of the lab teacher in charge of the laboratory. Two lab teachers took charge of the lab on the 11 schools, moving from one to another to attend classes during sessions. The variation in mathematics SIMCE achieved by one lab teacher was 20.14 points which corresponds to 7 classes, while the increase achieved by the other lab teacher was 18 points, corresponding to 8 classes. The t-test for independent samples reveals that we cannot reject the equality of means (N=15 classes). That is, the SIMCE math increase is statistically similar between the two lab teachers.

While the increase in SIMCE math is not explained solely by teacher or lab teacher effect, it remains to be analyzed what may have caused it. As in all schools in the Lo Prado district the model was implemented with one or two sessions per week, it is expected that the amount of exercises attempted had an effect on learning. Figure 2 shows the variation of SIMCE math in the 15 classes of the 11 schools of the district, as function of the number of online exercises with immediate feedback between end of March and early October 2011. In total, there were 185, 413 such exercises. Exercises with errors in their statements were discounted. Also were not counted exercises answered by a student in less than three seconds and in less time than the average response time minus two standard deviations. As seen in the chart there is a positive relation between number of exercises and increase in SIMCE math. The increase is of 15.3 points in SIMCE math per 100 extra exercises per student performed online. This means that for every 12 additional exercises done per month per student, the SIMCE math increases 15.3 points (0.306 standard deviations). The result is statistically significant with a p-value of 0.029.

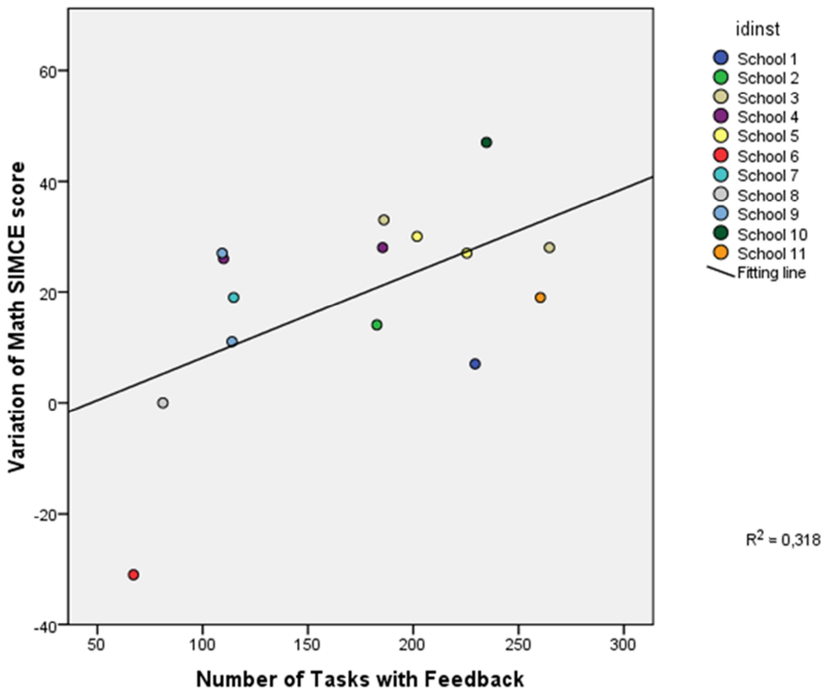

Figure 2: Variation on the 2011 SIMCE Math score of each class (N=15 classes) in function of the number of on line exercises with feedback made per student during the year from end of March to early October 2011.

4 Discussion

We have measured the impact of the adoption of a blended model focused on ensuring intensive student practice and on providing real time support from teachers and peers in all the 11 public schools in a low socioeconomic district. There are 203,782 records corresponding to the trace of on line math exercises done in 2011 by the 469 students in all the 15 fourth grades classes on these schools. The results are very promising and encouraging. First, there is a real measurable impact. The effect has been obtained not only by internal tests, but using the results of the national assessment test SIMCE math. This is a nationwide test, designed and administered by a completely independent team belonging to the Ministry of Education. The impact is very big. The increase was 0.38 standard deviations. This is more than three times the big and historic country wide increase on the SIMCE math of the year 2011. These results are in addition to differences in teachers. Moreover, there is a clear correlation between improvement and intensity of use of the ICT model. Classes that did more exercises with immediate feedback per student in the year they increased more their SIMCE math scores. This result agrees with studies in laboratory conditions, but now the results are obtained after a year of implementation in real schools and with low socioeconomic status students.

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