

## **Closing the Math Learning Gap between Chile and Developed Countries**

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### **Abstract**

Latin American students maintained a low achievement level during the 1990s in spite of huge investments in education, but significant increments in Chilean students' learning were the result of a carefully designed development project implemented in 2001-2002 in a high standard level K-12 school. The use of "interactive learning scripts (guidebooks)" plainly telling the actors (students and the teacher) "activities" to be carried out in each session (grades 1-8) made it easy for teachers to upgrade teaching methods. Less than 5% of the teachers were unable to adapt to the scripted methods while students kept demanding this "easier" way to learn. The external innovation team replicated methods used in the successful massive Colombian Escuela Nueva program, and supervised the project through a monthly two-day visit plus a local team monitoring of every day operations. Given that national test scores in Chile and Colombia are close to the average in Latin America, the findings of this project are relevant for the whole region and may be useful for other developing countries.

### **Regional Education Context: Too Many Efforts, But Little Improvement**

No real improvement in the quality level of Latin American education was observed in the last decade in spite of over 12 billion dollars financed in that period by World Bank and Inter American Development Bank to raise quality<sup>2</sup> (Schiefelbein & Schiefelbein 2000). Low scores in achievement tests administered in the late 1990s to a dozen countries (Cassasus et al. 1998; Schiefelbein et al. 2002) suggest that strategies used in those education investment projects were inefficient. The minor impact of education development projects financed by development Banks may be caused by lack of professional evaluation (Patrinos & Ariasingam, 1997; Schiefelbein, Swope & Schiefelbein, 1999) or perverse incentives to project officers

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<sup>2</sup> The 5% interest collected by Banks yields a gross revenue of 500 millions per year. Part of that income should be allocated to research for reducing wastage for ineffective investments.

(not linked to the educational outcomes, but to the number of loans and the amount lent). On the other hand development agencies have reviewed implementation of their past projects (Romain 1985), commissioned “state-of-the-art” reports on “what works” (Wolff & Castro 1999; McGinn & Borden 1995; Wolff et al. 1994; Velez et al. 1993; Schiefelbein & Simmons 1979), and studied the estimated cost-effectiveness of 40 strategies in order to get better strategies for improving education (Schiefelbein, Wolff & Schiefelbein 1998). The experience described in this article takes stock on these studies and findings.

The gap between developed and developing countries with respect to learning achievement, suggested unfavorable learning conditions in the latter. (Bloom 1976). “Frontal teaching”, lecturing to children seated in lines of desks that remain in silence to allow the never-ending voice of the teacher not to shout, thus avoiding throat pain at the end of the day, had been highlighted as one of the serious causes of the scant increment in quality of education (UNESCO 1992). Unfortunately, highly evaluated programs, like the successfully “scripted” Colombian Escuela Nueva (McEwan 1995; Psacharopoulos et al. 1995; Schiefelbein 1992), have not been widely replicated in the region. Moreover, Banks’ projects have not included the most cost-effective strategies estimated by a group of ten world experts<sup>3</sup> (World Bank 1995). Those experts agreed that countries should undertake interventions, which are more cost efficient, while having a positive impact (Schiefelbein et al. 1998). For example, they recommended that the best teacher should be assigned to the first grade in order to help students to learn to read as well and soon as possible. The experts also noted the need for students to have enough time to learn therefore suggesting that the official length of school year should be extended. The third priority was given to a policy to not switch classroom teachers during the year. These low cost strategies have not been included in any of the projects financed in the region in the 1990’s.

In 1990, the time was ideal for improving quality given that 95% of the children were enrolled in school and achievement was low (Schiefelbein 1989; Schiefelbein & Grossi 1981). Building schools and hiring teachers increased coverage, but did not change classroom processes. Therefore, half of grade 4 students were not able to understand even a simple paragraph in the first page of their national newspaper (UNESCO 2001; OECD 2000; Schiefelbein 2002; Harbison & Hanushek 1992). Low reading comprehension also limited learning math. Even though this poor educational outcome is fully documented, mass media has not kept public opinion well informed (Chapman & Mahlck 1993). However, the private sector is now competing in a global economy and requires better-educated workers (ECLAC/ UNESCO 1992). Thus, there is mounting pressure for improved education (OAS 1998; UNESCO 2001; Schiefelbein & Tedesco 1995; Schiefelbein 1995; McGinn 1990). It is opportune to report experiences that have improved achievement levels in order to design efficient massive strategies.

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## **The Chilean Education Context and Policies: Looking for the Cause of Poor Learning**

Achievement levels in Chile are far below the average level of developed countries in spite of large investments, but are close to the Latin American average. This quality gap means that the labor force is not being able to: read manuals describing the way to operate the next generation of machines; learn about safety instructions and health care; or learn about the use of available social services (Bravo & Contreras 2001). A long-term national debate pertaining to the low quality of Chilean education was systematized in 1994 by appointing a “National Commission”. The commission recommended to extend the time for learning and to rectify the traditional “frontal teaching” addressing the whole class so that every student would be able to keep up with the pace of the teaching with alternative approaches (Brunner et al. 1994).

Achievement levels had not increased in the 1990’s in spite of serious efforts: doubling teachers’ salaries, increasing the daily schedule by 40%, providing textbooks, creating a computer network for over half of the schools, funding school based projects, and testing all students in grades 4 and 8. The democratic government elected in 1990 implemented two massive programs: P-900 that offered remedial activities to deprived schools and MECE that furnished equipment and classroom libraries, and granted funds to school-designed projects. The P-900 program was implemented in the 1990-1999 period at 46% of schools operating with four or more teachers, but was not able to increase achievement over 60% (about 50% if “correct answers by chance” are deducted) of the expected curriculum goals (Raczynski et al. 2000, p.34). Even though there is no direct evaluation of the MECE program (as most World Bank development projects), available evidence suggests that its impact has been limited.

The quality gap with developed countries has been almost constant (even broader in reading) in the last three decades. National Testing introduced in Chile in the late 60s and developed in the 80s and 90s (Schiefelbein, Wolff & Schiefelbein 2002; Chapman & Mahlck 1993; Schiefelbein & Farrell 1982), together with the participation of Chile in international testing surveys since the early 70s (Keeves 1988; PISA 2003), provides a precise record. The 1970 Chilean students performed at about 90% of the average of high-income countries in reading and 65% in sciences (Lockheed & Verspoor 1991, p.8). The magnitude of the quality problem in 1999 is well illustrated by the achievement scores in reading. Grade 4 students answered “correctly” about 60% of four-choice items on reading comprehension (SIMCE 2003). But these answers included 10% of “answers correct by chance”. Besides, most reading problems concentrate in the lower half of the socio-economic class. Therefore, some three-quarters of students from poor families are not able to read with an acceptable comprehension ability nor able to perform simple mathematical operations and reasoning. Fortunately, the language of instruction is the same as the home language for 90 to 95% of learners. Bilingual education in two indigenous languages (Mapudungun and Aymara) are being considered in areas where Spanish is not the native language. It is likely this recent

policy will improve learning of indigenous groups.

The 1999 Chilean math scores were about 80% of the international average (Mullis et al. 2000). TIMSS 99 reported an average score of 392 for Chile on a scale with a 500 mean and a standard deviation of 100. Similar differences were reported in a UNESCO-OREALC survey (Cassasus et al. 1998). Therefore, the targeted curriculum seems to be adequate or even “easy” with respect to international standards. However, teachers do not have learning materials for generating enough opportunities for deep understanding of concepts and practices, and for relevant applications of students’ learning.

Four facts constrained the search for effective solutions to specific curriculum issues. First, public opinion was not aware of the magnitude of the problem and the constraints for solving it. Second, “conventional wisdom” assumed that the “average teacher” can and should solve, alone, any education challenge. Third, examples of efficient education practices are not available for teachers to understand their main elements and use them in their classroom processes (Chapman & Mahlck 1993). Fourth, decision-makers are only confident on “local creativity” or previous national experiences or hunches. In 1990 the UNESCO Regional Office for Latin America in a joint effort with UNICEF gave the Ministry of Education of the new democratic government a grant for ten educational leaders to visit the successful Colombian Escuela Nueva experiment (Colbert et al. 1993). Acceptance of the grant was delayed for two years and eventually only four educators did travel there. The educators found that the Escuela Nueva approach was highly effective to cope with Chilean education problems and eventually some elements were integrated in the reform activities. However, key innovative elements were not implemented such as learning materials to be handled by students; systematic group work to personalize teaching; students developing relevant projects; giving options to students; producing daily relevant writing; and interesting parents participating in working with their children and the school.

In summary, infrastructure and learning time were apt for delivering fair universal primary education, but little had changed in classrooms, and public opinion was not aware of key educational issues. Therefore, the innovation strategy should be focused on the curriculum issues discussed in the next section.

### **Curriculum Issues in Chile (when key inputs are available for basic education)**

Math is considered the “difficult content area” and a screening device for student promotion to the next grade. However, math curriculum for grades 1-8 covers the usual skills on operations with natural and rational numbers as in most countries, because “in primary schools, the composition of the curriculum is remarkably similar world-wide” (Lockheed & Verspoor 1990, p.31). The “intended” math curriculum was revised in 1996 to foster problem solving abilities, but the “implemented” curriculum is still mainly focused on operating numbers (using algorithms) rather than on reasoning involving mathematical operations.

Some 20% to 25% of the weekly school schedule ranging from 25 to 35 chronological

hours is allocated to acquisition of math skills, five to eight sessions of 45 minutes per week. However, one-third of available learning time is used for non-education activities and usually less able students do not participate. Pre-service teacher training does not develop teachers' ability to generate interesting learning experiences or to evaluate ongoing learning and give enough time and drilling to students in the lower half of the "talent distribution". There is no "math for all", because only talented students master fundamental math abilities. For example, all grade 4 students know how to add two single-digits numbers, but only a few know the use of the operation in the solution of simple problems like "how many birds were in a flock if four perched in a tree and two keep flying". As soon as the wording of a problem changes, students cannot find the right answer. Even good students "perform adequately so long as a problem is stated in a certain way allowing them to 'plug numbers' into an equation or formula without worrying about what numbers or symbols mean" (Gardner 1991, p.161). Thus, it is necessary to prepare students to explore the relations between the key elements included in each problem (to distinguish between key elements and distracters or irrelevant elements with respect to the problem under analysis) linking this ability with "reading comprehension".

Poor learning detected in the national testing system (SIMCE) is not necessarily reflected in high repetition. Teachers mark the exams and pass their students to the next grade according to their subjective judgements (McGinn et al. 1992). "Automatic" promotion from first to second grade enacted in the late 60s reduced repetition rates from 40% (Schiefelbein & Davis 1974) to only the current rate of 10%. However, the problem is to improve the poor learning that causes repetition. The P-900 massive remedial program for primary schools that perform in the bottom according to the national testing system, has been able to improve the achievement scores by 10% to 20% in two thirds of the schools, but one third of the schools have not improved (Gutman 1993; Raczynski et al. 2000, p.35). Even though P-900 was designed based on careful experimentation carried out in the early seventies (Vaccaro & Schiefelbein 1981), its performance has not been constantly evaluated with a reliable design.

Expectations for implementing the revised 1996 math curriculum were too optimistic. Because wider dissemination of the main ideas was limited, brief in-service lecturing was more of the same frontal teaching, and "education improvement projects (EIP)" did not go beyond the school level. Resources up to US\$10,000 (according to the size of the enrolment) have been granted to each school for implementing its EIP. Implementation of EIPs has been followed up, but there is no help for local schools to improve their teaching methods or find reliable supervisors or consultants. The ENLACES computer network supplied access to an excellent encyclopaedia, but the network had no mechanism (web site) for teachers to exchange descriptions (representations) of their best classes. Therefore, no "*users' friendly*" ways for teachers willing to improve their methods to find help for designing and delivering better classes were available.

Unfortunately, the revised math curriculum presented in textbooks, distributed free to all students, has a small amount of required exercises to master each topic; no time suggestions

for each topic; no connection to local context; and does not describe how to evaluate the mastering of each problem-solving skill. More relevant examples and precise instructions for evaluating the learning of each of the students are required. This is a key aspect because teachers have never been trained to get all students, or at least 90% to reach the expected curriculum goals.

In summary, even though inputs were available, curriculum goals could not be achieved because there were no improvements in classroom processes, learning materials, or the capacity of teachers to adapt to the new demands. Given that the targeted curriculum was similar to most developed countries the focus should be on teaching, not standards setting *per se*. Successful experiences were required to close the gap between the intended curriculum and classroom processes. Therefore, the goal of the development project presented below was to raise achievement in two years, to close the gap with developed countries, so that other teachers may have detailed learning materials (scripts or guides) for implementing similar processes.

### **The Local Setting: A School for Children of Professionals Living in an Isolated City**

A better than average school was chosen for the project to show that higher achievement levels could be attained in Chile. These higher levels of achievement are expected to close the quality gap with developed countries. There is a large copper mining company near Calama city that hires top engineers, geologists, managers, computer specialists, lawyers, and other professionals. Jobs are interesting and most candidates are willing to move their families into the isolated small city of Calama if their children can enroll in a high standard school. The copper company operates a private school that obtains a voucher subsidy per student from state funds (Castaneda 1986; 1990), but the company provides further support to pay teachers higher salaries to attract good teachers to an isolated city. The school provides both basic K-8 and secondary 9-12 education in a modern campus. The school enrolls 2,200 sons and daughters of copper mine workers, therefore no screening is allowed.

In spite of good material conditions achievement scores in the SIMCE system for grades 4 and 8 and those in the University Entrance Examination (PAA) were above the national averages, but not among the best 100 Chilean schools. For example, the school was ranked 150th in 1999, grade 4 SIMCE test and scores were 5% higher than other schools with similar characteristics and 22% higher than the national average (SIMCE 2003). The school board feeling the pressure for better quality of education searched for specialists able to boost performance in schools with similar characteristics. Our team was selected by the school board and started to work in late November 2000. The team prepared a diagnosis based on a visit to the school that included actual work with students. The upgrade proposal was focused on grades K-8, about 150 students in four parallel sections in each grade. The school board approved the proposal and our team started the development project early December 2000, just prior to the January and February summer vacation.

## **The Theoretical Background: Focusing in Deep Understanding and Slow Learners**

The innovation team had already developed and evaluated learning scripts, in language and math, to cope with three frequent “constraints” observed in the teaching and learning of mathematics:

First, to learn mathematics implies to accept its own “particular practices and approaches which have developed over its lengthy... history” (Gardner 1991, p.8). Some of these practices are not intuitive for many learners. In fact, learning mathematical operations can prove vexing. It is not intuitive that in a sequence of numbers 0.6 is greater than 0.59999 (Gardner 1991, p.162). In fact, it is a tough task for students to really understand certain relationships, for example between two decimal numbers or fractions.

Second, to move from the usual rote, ritualistic or conventional performances to genuine disciplinary understanding a wide variety of applications must be presented to students. Those applications allow students to be “able to take information and skills they have learned in school or other settings and apply them flexibly and appropriately in a new and at least unanticipated situation” (Gardner 1991, p.9). This implies that more time and activities must be allocated for slow learners.

Third, to cope with “the relative absence in schools of a concern with deep understanding” of mathematical concepts and practices (Gardner 1991, p.8). In most schools, students credited with understanding of a certain topic have not really reached a genuine degree of understanding. Teachers jump into the next task in order to “cover” the program, not being really sure that all children obtain the ability to succeed when problems are expressed in wording that differs slightly from the expected form. Successful understanding implies nonstop evaluation of performance and monitoring the advance of students toward more complex applications.

The innovation team acknowledged that in Calama School there were three groups of students in each class room: (i) the quick learner who is well equipped to master most learning tasks as soon as presented; (ii) the average learner who is able to reach a reasonable understanding with a small number of exercises; and (iii) the slow learner that needs to be trained with a variety of sequenced exercises that includes many alternative applications covering the whole spectrum of curriculum objectives. As worked out in previous development projects, where the learning scripts had been developed and evaluated, the innovation team gave “inequality of treatment”. Mainly sufficient time for slow learners to achieve mastery to be sure that students attain equality of learning outcomes (Bloom 1976, p.4 & p.215). Eventually, group cooperative learning may also be a complementary strategy (Slavin et al. 1989) to be used when teachers feel confident in a teacher-controlled use of available learning materials.

Learning scripts have been instrumental in previous successful programs, including Escuela Nueva and applications in Chile, by including enough exercises to be sure that understanding be achieved. Scripts describe step by step the activities that *the learner should do* to make the learner actually learn. For example, events that help students to realize that if

one worker spends 4 hours cleaning 20 windows, two workers of same ability will do the job in 2 hours less chronological time, but same amount of work. Other representations may help students that can do calculations “with numbers and with money but are unable to connect the two realms” (Gardner 1991, p.164). Scripts not only show “sound” procedures, but help the student to understand what is involved, and provide examples for exploring the semantic domain related with the problem being analyzed. Certain counter intuitive concepts are fully analyzed and complemented with relevant applications. For example, students associate the result of multiplying with a larger product; however scripts helped students to realize that the result of multiplying fractions is smaller than each of the factors.

Activities to understand the relation between words and numbers were proposed in math scripts and complemented with language scripts. “One stumbling block ... in mathematics learning involves the precise meaning of words ... For example, ‘twice as less’ cannot be equated with ‘half as much’” (Gardner 1991, p.162). Therefore, language scripts were instrumental in developing the ability to understand written messages. Moreover, math scripts included disciplinary contents as well as values and linkages with context. For example, a mathematical problem dealing with “an old lady drops a basket with 8 oranges and loses 3 of them” allows a value discussion about laughing for such a bad luck of the old lady.

Performing proposed participation was always followed by feedback and reinforcement to ensure that each student gets the expected high quality of instruction, because presenting information to a passive learner is not likely to produce much in the way of learning. Scripts included series of exercises that train the student in finding what is actually at stake when they are posed a problem. They are presented as games in which the student should avoid distracters or diversions built into the problem in order to identify the true challenge. In some cases learning a new ability may take a long time. For example, considerable drilling is required to learn the ability to systematically solve “in words” the result of the following problem: “*If Peter had three apples and Mary gave him two additional apples. How many apples does Peter have?*” We found that students should perform 40 to 60 written exercises before handling this simple reasoning with addition. In summary, the scripts combined a rigid application of each algorithm with a set of exercises that helped students to understand how algebraic expressions can capture and analytically represent a given situation.

Even though scripts were checked against precise criteria (Darling-Hammond 1997, p.107), the final proof of their quality was the amount of learning experimented by children measured in worksheets where their own learning is recorded as correct and wrong answers and in periodical objective testing. The design and testing of the scripts used in this project was carried out with “real students” during the 1990s, as in the Sesame Street series (Truglio 1999). In addition each time scripts were used with a new group of students the teacher was asked to record any problem detected in their use or new ideas for improving their design, accumulating best practices. In short, math learning scripts were presented as a tool in constant evolution for raising quality of education.

## **Six Elements Linked with Successful Implementation of the Development Project**

Learning scripts, agreement on specific learning objectives, demonstration sessions with students, monitoring, objective evaluation, and clear rules for a local supervising team were the main elements for successful innovation in Calama School. The driving forces were using well tested learning scripts for grades 1-8, clearly describing activities to be carried out in each class, and minimizing additional work for teachers to implement the changes (Bloom 1976, p.5; Colbert 1993). Calama teachers were aware of the local pressure for better quality and soon realized that scripts would help them deliver better teaching. The scripts provided learning activities for half of the school time allocated to mathematics, while teachers used the remainder time according to their experience and wishes.

An early agreement between Calama teachers and the innovation team upon a “specific set of objectives” and sequence reduced stress from unknown demands. The scripts were then adapted to those objectives, mainly sequencing as agreed, and made available for the school teachers to use them if they wish. Teachers decided to use scripts because they made their task easier, and utilized the scripts in the sequence they wanted to work.

“Demonstration sessions” with real students made evident the way the learning scripts should be used. Moreover, learning scripts instructions for students and teachers were also a ceaseless source of training in effective use of new teaching techniques. For example, a powerful new technique in each class is continuous formative evaluation using written answers in worksheets. Relevant exercises for the topic of the class were performed by students until over 95% of the class was able to perform as required, while two or three students with problems in keeping the pace of the class were coached later on by a remedial team. In one out of three or four classes recreational math scripts were used to keep students’ interest in math as a relevant and challenging topic. Teachers attended an initial demonstration class in March-April 2001 and later their classes were visited and feedback provided. The innovation team showed that through a very relaxed participation students dramatically improved their performance with a relevant and interesting sequence of exercises. Moreover, the learning scripts were easy to be implemented by teachers and represented no threat to them.

Several mechanisms for monitoring the process were also implemented. Each student kept a folder with her/his “answer sheet papers” where the student himself/herself or a classmate marked the mistakes. Therefore, parents or the reinforcement team could help each student in their specific problems because they were clearly identified. Reporting student achievement in each session, according to the student’s “worksheet”, allowed quick appraisal of each class performance. Afterward teachers gave up the worksheets to a secretary to avoid incrementing teachers’ work, got them back the next day and returned to students for filing results in their folders. Monthly visits of the innovation team to classrooms provided opportunities for detecting main problems such as: regression in working only with good students, less time for the slower learners, lack of enough exercises for slow learners to reach the “deep understanding” level, or reduced “expectations”. Finally, an end of semester objective test exogenous to the class teacher, was instrumental in ensuring fair advance in

each classroom.

At the outset, a local innovation team was organized. A small team of four top local staff received in-service training to follow up the experience in each classroom. However, the external team visited the school once a month and coached teachers in their classrooms to be sure that the scripts were effectively used. Formative evaluation was carried out after each exercise, that students marked with a non-erasable pen. To monitor performance, correct and incorrect answers were recorded and a summary percentage of correct answers were recorded after each class.

### **Monthly Visits as “Stepping Stones” of the Implementation Process**

Implementation started with a classroom demonstration of what students could achieve with the learning materials provided by the external team. This was complemented with hands on training of teachers, and continued with frequent local monitoring during the whole process. In the first two day visits of the external team in late November 2000, just before the end of the school year in December, it was made clear that there would be no imposed changes, but teachers were invited to evaluate the materials and methods which they would use (Gardner 1991, p.140). This was followed by a visit to a class group. One member of the external team was granted permission by the classroom teacher to work with her students, while the rest of the team stood in the back of the class. Evidence was produced that many students knew basic math operations but could not apply them in simple everyday problems. In the ensuing meeting with the local team questions were answered and a second visit was planned for December 2000.

The agreement on learning tasks that students should master in each grade was reached during the December visit with each of the teachers working with each of the four parallel courses. The basic elements of those objectives were identified and the relations among the elements made explicit (Bloom 1976, p.23). Besides, the local team was asked to allocate additional time for learning math. The local team worked out to increase from 5 to 8 class sessions (45 minutes each) per week. Language was also allocated a similar increment in learning time. There was, also an active learning training session, hands on didactic methods for all teachers to prompt teachers utilization of new teaching approaches. Participants completed a form to evaluate the session and wrote questions about the innovation process. Many recommended using a participant (constructive) approach during the session.

The external team adapted scripts to the specific requirements agreed with the Calama teachers during January and February 2001, while the school was in summer vacation. Then special arrangements were made for massive printing of the learning scripts. Some 10 pages were required each day for each student. The 1,000 students initially involved in the innovation process needed some 10,000 pages each day (some 2,000,000 copies per year). It was a huge effort to bind, perforate, and distribute such numbers of copies. Even though this area was carefully analyzed and planned in March 2001, it was necessary to reshape the process.

The third visit was scheduled for the beginning of the new school year in March, 2001.

Systematic class demonstrations by the students while the teacher was sitting in the back of the classroom, were instrumental in reducing teachers' fear of not being able to cope with "new methods". The local monitoring system was agreed upon and a new "training meeting with all teachers" was carried out to legitimize the professional "leadership" of the external team beyond oral or written information about the team.

During the April-July visits, the process continued in three stages. First, scripts focused on "knowledge types of learning" were made available to teachers. Second, after teachers had used 10 scripts with advice on how to maximize benefits from their usage, and in addition new scripts on reasoning and comprehension were added as a special assignment for a few selected teachers. Eventually, all teachers started to use these new scripts. Third, more complex scripts with emphasis on application and analysis were also made available to teachers. This period ended up with the two-week winter vacation.

The August-December visits were focused on objective evaluation, monitoring processes, and surveying interest of students and parents. A mid year objective test was built by the team to check mastering of the whole array of objectives, to complement monitoring by comparing advances in each of the four parallel classes. Achievement scores increased by 10% with respect to the first semester 2000. Moreover, each visit was an opportunity for the demonstration classes, observing local teachers performances, and identifying aspects that the local team should remind teachers to upgrade. The team emphasized the need for reporting student progress through formative evaluation, but did not take teachers' extra-time for such activity. For example, by handing out student's worksheets to a secretary that typed the correct/incorrect answers in a data bank.

Innovation is an unending process, and in 2002 scripts were improved and reading and writing activities were enhanced. However, the goal of the project, raising the scores in a sustainable way, required to minimize interventions. Therefore, there was no attempt to include games that involve measuring, counting, and comparing, nor activities like cooking that require arithmetical operations. "Telling time, going on a trip, buying food ... for a party, and measuring clothing are but a sampling of the many other activities ... that call for the use of numbers." (Gardner 1991, p.212). Math scripts could have been eventually complemented with "units" or "projects" in social sciences concerning costs and resources as well as decisions. Among the topics to be dealt with would be waste disposal, transportation, nutrition, health care, or third-age care.

## **Main Findings during the First Year Implementation Process**

Students raised their first year achievement scores, because teachers were willing to innovate when they found that the scripts were reliable and its usage did not take part of their free time. Moreover, the number of students being sent to remedial classes was cut in half; the number of teachers' leave of absences was reduced, and teachers' classrooms could be visited and methods discussed. Such improvements were achieved in school year 2001.

Students' achievement scores improved approximately 10% in objective tests of similar

difficulty to those applied in SIMCE 1999. Moreover, surveyed students reported they were learning in an easier way than before and demanded that the scripts be used in other subjects. The rate of student attendance in grades 1-8 in the March-July period increased from 87.0% in 2000 to 93.7% in 2001.

Slow learners were reduced from an average of 6 per class (approximately 20%) to only one or two students, approximately 7%. Exercises gradually increasing in difficulty, allowed many slow learners to catch up. As expected (Bloom 1976, p.174), the “variation in achievement” under the favorable and precise learning conditions provided by the scripts was much smaller in 2001 than in 2000. This finding suggests that the incremented time for learning math and language could be eventually reduced once students from lower grades were better prepared each additional year for starting the next grade.

These indicators suggest an active involvement of teachers. Reporting was not a problem given that it did not increase teachers’ work load. Visits to classrooms were not associated with administrative controls, but with professional cooperation among colleagues. However, the clearest signal of teachers’ acceptance of proposed changes was the increased attendance and the reduction in leave of absence. There were 49 sick leaves in April-August 2000 and only 24 in a similar period in 2001. Such reduction in leave of absence seemed related to the higher achievement level of students. In summary, teachers felt fine in performing a new style of teaching and appreciated receiving feedback at the classroom level given the better than usual students’ outcomes.

Surveys carried out among students, teachers and parents showed that over 90% were supportive of the project. However, changes were constantly checked at the classroom level, to avoid “regressing to traditional approaches”, even the scripts could be transformed into “frontal teaching” not allowing students to do the required work before moving into the next exercise. Furthermore, the analysis of student worksheets and testing reports kept the remedial team focused on the specific learning problems.

Learning was not externally evaluated the first year, but all indicators were positive and consistent. Minister Mariana Aylwin and Vice-Minister Jose Weinstein visited the project in late 2001 and developed a contest among all groups working in raising achievement for deprived schools. However, it was necessary to wait for results of the next SIMCE to be administered in November 2002 for an objective analysis of the impact of the project.

## **Main Findings at the End of the Second Year: The National SIMCE Results**

The external national SIMCE test administered to 124 fourth grade students, published in May 2003, showed that Calama School was ranked 77<sup>th</sup> in the country, improving from the 150<sup>th</sup> position in the previous test of 1999. The ranking according to the average score in “math and language”, improved from 133<sup>rd</sup> in 1999 to 99<sup>th</sup> in 2002 (SIMCE 2003).

Absolute increments in the SIMCE scores in language, from 304 to 311, and in mathematics from 306 to 309, are more difficult to interpret because Calama School was already performing in the upper decil of the distribution of scores where increments are

more demanding. Thus, a relative increment ranking gives a better idea of improvements.

It can be assumed that the gap with developed countries could be reduced, because these improvements were measured in a high achieving school with respect to Chilean standards, but below the average in developed countries. Furthermore, improvements in deprived schools should be much higher, and eventually variability in scores should be reduced according to Bloom's ideas. Fortunately, the Ministry of Education implemented the idea of a "contest for improving achievement" in the 66 lowest scoring schools in the Metropolitan area. Thus, we started in 2002 a new development project in seven of those schools, other six teams are participating in the competition. Our team accomplished the highest increment, of 10% in the first year. We expect to report a significant success at the end of the project in 2005.

In summary, the limited magnitude of the project and its straightforward implementation, given that the changes are embodied in the interactive learning scripts, suggest that this approach can be massively applied in a variety of schools in any developing country willing to cope with low achievement levels.

### **Seven Conclusions Based on the Previous Findings**

Higher math achievement scores can be attained in basic education if relevant "scripted" materials (guides) are available for teachers to reach a set of agreed objectives, and those teachers have the opportunity to see "demonstrations" of the effective use of those materials with their own students.

Teachers were willing to innovate by freely using relevant easy-to-use "scripted" materials. Therefore, the cost of better teaching was closely associated with the careful development of those materials including testing of learning by real students, rather than with in-service training for developing general ability of teachers. Additional time allocated to learning math and language could be gradually reduced once better prepared students are promoted to upper grades.

Demonstration of new classroom processes raised teachers' confidence on the reliability of proposed methods and confirmed that implementation would not demand extra time. But monitoring was instrumental to keep using formative evaluation in each class, focusing time in stumbling blocks shown in worksheet answers, raising expectations, or accumulating successful approaches in written scripts.

Improvements were detected in less than a full school year, given that teachers felt fine in performing a new style of teaching. Also, improvements upheld at the end of 24 months, even though only small changes and monitoring were made in the second year. There is still a question of whether the improvement is permanent or it will burn out after a certain number of years.

Attaining the agreed set of mathematical knowledge and skills required drilling and systematic teaching, but also to link learning with contexts in which the use of knowledge and skills makes sense. Learning activities included opportunities for students to realize

that mathematics could be used productively at home or in everyday life.

The relevance of mathematical knowledge was closely linked with student's motivation and perseverance to finalize the required exercises and applications. Analytical approaches were complemented with undertaking numerical calculations, geometrical problems or illustrations, and plain language reasoning. Best practices were improved in the application and, eventually, alternative scripts could be available for students with specific characteristics.

Given that Chile's scores in international surveys (TIMSS, PISA or IALS) are close to the average of Latin America, these findings may be relevant for the whole region. Achievement scores in language and math measured only part of educational outputs, but the strategies used in this project can help developing countries to attain at least minimum cognitive goals.

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