A Monitoring and Evaluation Scheme for an ICT-Supported Education Program in Schools

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ABSTRACT

More than 20 years after ICTs were introduced in schools, solid evidence of their impact on student attainment is still lacking. Reasons for this include the mismatch between the methods used to measure the effects and the type of learning promoted, the absence of information regarding the specific types of ICT used, and the scarce attention paid to the monitoring and evaluation of ICT for Education (ICT4E) programs. A monitoring and evaluation scheme would provide qualitative and quantitative data to refine, adjust and improve an ICT4E project, to learn from the experience gained, and to determine whether the program has served its client communities and how it might be replicated.

In this paper we present a monitoring and evaluation (M&E) scheme for a specific ICT4E program that supports teaching and learning using mobile computer supported collaborative learning (MCSCL). Using the information provided by the scheme, we analyze the program's impact on student attainment in terms of teacher adoption of innovation. It was found that there were statistically significant positive differences in students whose teachers showed higher adoption levels when compared both to lower adoption cases and other defined control groups. We conclude that an M&E scheme supports the intervention process by providing real-time information for decision making through the application of assessment instruments according to a monitoring plan. This enables intervention activities to be adjusted so as to ensure an adequate level of adoption.

Keywords:

ICT, education, monitoring and evaluation, adoption, collaborative learning

Introduction

Information and communication technologies (ICTs) arrived in schools more than 25 years ago (Robertson, 2002; Reynolds et al., 2003). The general perception has been that they would increase levels of educational attainment by introducing changes in teaching and learning processes and strategies, adapting them to the needs of the individual student (Sunkel, 2006). During the nineties, investments in ICT grew in response to the rapid rise of the Internet and the World Wide Web (Pelgrum, 2001) and as an effort to bridge the social inequity between people with and without access to ICT, also known as the digital divide (Warschauer, 2003).

There are four commonly accepted rationales used to justify investment in educational ICT: support for economic growth, promotion of social development, advancement of educational reform and support for educational management (Kozma, 2008). These rationales are still not backed by any strong evidence of ICTs' impact on student attainment, however, and whether the manner in which ICT is implemented impacts on students' knowledge and understanding has yet to be unambiguously determined (Trucano, 2005; Cox and Marshall, 2007).

There are at least three reasons for this lack of evidence. First, there is a mismatch between the methods used to measure effects and the type of learning promoted (Trucano, 2005; Cox and Marshall, 2007). Researchers have looked for improvements in traditional processes and knowledge instead of new reasoning and new knowledge which might emerge from ICT use (Cox and Marshall, 2007). Second, although some large-scale studies have found that ICTs have a statistically significant positive effect on student learning (Watson, 1993; Harrison et al., 2002), it is not yet possible to identify which particular types of ICT use have contributed to these gains (Cox and Marshall, 2007). To clarify this would require specific information about these technologies and the ways teachers and students are using them.

The third reason for the dearth of evidence is related to the fact that monitoring and evaluation (M&E) are not receiving the attention they deserve (Trucano, 2005). The monitoring of an ICT for education (ICT4E) program examines what and how is being done (*fidelity of implementation*) (Wagner et al., 2005), while evaluation analyzes the immediate or direct effects of the program intervention and implementation (Rovai, 2003) in order to measure performance. The central elements of an M&E scheme are indicators and assessment instruments (Wagner et al., 2005). An *indicator* is a piece of information which communicates a certain state, trend, warning or progress to the audience (Sander, 1997) whereas *assessment instruments* furnish that information in a specific context (Wagner et al., 2005).

The main role of assessing fidelity of implementation is to determine whether an ICT4E program is operating as intended in overall terms (Rovai, 2003; Wagner et al., 2005) and in line with the program designers' specific intentions (Agodini et al., 2003). For this to be possible, the designers must first specify which are the important or critical features teachers have to enact in their classrooms and then develop measures for establishing whether and how those features are put into practice in real classrooms (Penuel, 2005). M&E can then provide a deeper understanding of the relationship between variability in the implementation of a program and its measured effects (Agodini et al., 2003; Penuel, 2005). They are also able to identify the limits of a program's applicability or flexibility and possible flaws in the assumptions underlying it (Penuel, 2005; Light, 2008).

During the implementation of an ICT4E project, a well-designed M&E scheme will be feeding back qualitative and quantitative data to the project managers, who can then use this information to refine or adjust the project (*formative M&E*), to learn from experience, to determine whether the project has served their client communities and how it might be improved in a later phase, or perhaps how it might be replicated (*summative M&E*) (Batchelor and Norrish, 2005).

Therefore, if a new ICT4E program demonstrates positive improvements in learning, the implementation of the M&E scheme will be critical for scaling-up the project. The scheme will facilitate an understanding of both the context (Penuel, 2005; Light, 2008) and the program's everyday operation in real-world conditions rather than just an educational experiment that creates an environment which "shelters" the project (Castro, 2004).

In the remainder of this paper we present the design and implementation of a M&E scheme for a specific ICT4E program based on a mobile computer supported collaborative learning (MCSCL) initiative. We begin in Section 1 by defining M&E schema for ICT4E programs generally. Next, we describe the MCSCL-based program and its specific M&E scheme, setting out the indicators and assessment instruments developed and its validation in terms of the relationship between adoption indicators and program effectiveness. The paper ends with the main conclusions and possible directions for future research.

What is a monitoring and evaluation scheme?

Every ICT4E program should distinguish between its intervention and implementation phases. The objective of an *intervention* is to develop the necessary autonomy in the teachers and students for using an ICT-supported pedagogical model, adapting and even modifying it to fit the context. This involves developing activities such as teacher training, hands-on experiences and class observations in accordance with an intervention plan. *Implementation*, on the other hand, is the process by which teachers and students apply the model in their work.

An M&E scheme assumes that the ICT4E program to be monitored and evaluated has already demonstrated the effectiveness of the intervention and implementation processes. In other words, that teacher training has a direct impact on their skills and the implementation by teachers of the ICT-supported pedagogical model has a direct impact on student attainment.

The objectives of an M&E scheme (Rovai, 2003; Trucano, 2005; Wagner et al., 2005) are: 1) to measure the implementation fidelity of the intervention to the original program design; 2) to assess the outcomes of the ICT4E program; and 3) to provide information for decision making during the intervention. The elements constituting such a scheme (Wagner et al., 2005) are as follows:

- *Input indicators:* These measure the basic conditions for implementing a given ICT4E program, e.g., computers per student ratio, bandwidth access. Some of them can also serve as a baseline for the intervention, e.g., teachers' ICT skills. All of them must be assessed at the beginning of an intervention at a school to evaluate whether the requirements for ensuring process sustainability over time are in place.
- *Process indicators*: These track the evolution of ICT integration. There are two types: intervention indicators and adoption indicators. The former measure the extent of compliance with the intervention plan while the latter measure whether the skills for implementing the ICT4E program have been acquired by its actors. Adoption indicators thus monitor the critical features that teachers must enact in the classroom (Penuel, 2005) as it is these factors which determine the outcomes of the program, especially those concerning student achievement.

- *Outcomes*: These indicators reflect the direct impact of an ICT4E program (*e.g.*, teachers' skills acquired through training) and its implementation (*e.g.*, improvement in students' attainment). Some outcomes can be expressed as threshold values reached by process indicators (*e.g.*, if a process indicator is teachers' confidence level using technology, an outcome might be that this indicator reaches an average above 80%).
- *Assessment instruments*: These constitute the tools for measuring input, process and outcomes indicators such as performance tests, observation protocols and surveys. Instruments can be quantitative or qualitative, depending on what is being assessed.
- *Monitoring plan*: This is the schedule for measuring indicators, applying assessment instruments and implementing process evaluation. This is the most critical part of applying the framework since some indicators are complicated or costly to measure, making frequent readings impractical.

The approach to M&E described above is similar to the CIPP (*Context Input Processes Products*) model (Stufflebeam and Shinkfield, 2007) in that it combines several types of evaluation: input, process, output, and impact (Rovai, 2003).

The experience of previous implementations of ICT4E programs should give designers a non-explicit idea of the evolution of adoption indicators. The objective of developing an M&E scheme is to transform the designers' procedural knowledge into declarative knowledge, defining the levels to be reached for each adoption indicator at given moments during the implementation. This is illustrated in Figure 1, where the vertical-line shaded area represents the range of values taken on by an indicator (according to previous experience) while the black line tracks the evolution of the indicator via discrete assessment during a given intervention. Periodic measurement of the indicators' actual values provides accountability regarding the effectiveness of intervention and implementation processes and should therefore detect any deviation from the expected evolution.

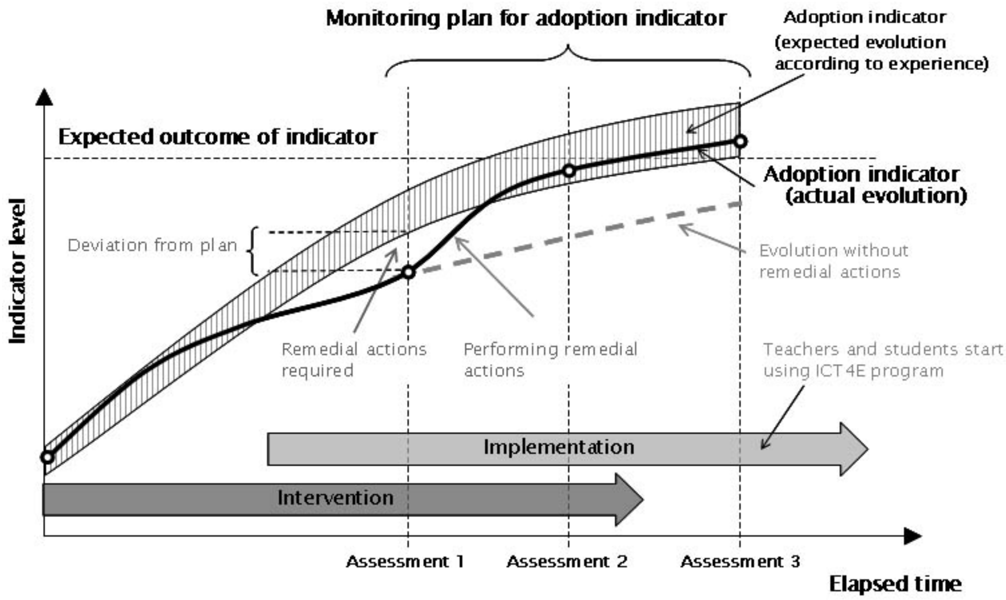

Figure 1: Each process indicator is assessed according to the monitoring plan, detecting any deviation from the expected evolution and performing remedial actions where needed.

Continuous comparison of the ideal evolution of the adoption indicators with their actual evolution will allow adjustments to be made to the intervention so that any negative trend (dashed line in Figure 1) can be corrected. The monitoring plan should balance the frequency of measuring an indicator with the associated cost. In the present case, the outcomes are the skills acquired through training, coaching, ICT support and other efforts.

Developing a monitoring and evaluation scheme for an ICT4E program

This section describes the development of a specific M&E scheme for an ICT4E program. We begin by briefly presenting a program known as Eduinnova and then define each element of an M&E scheme created specifically for it. We conclude by discussing the results of the implementation and how they are related to teacher adoption of the program.

Eduinnova

The pedagogical model behind the Eduinnova program is based on mobile computer supported collaborative learning (MCSCL) (Zurita and Nussbaum, 2004a, 2004b, 2007). It is intended to enhance the learning experience inside the classroom through face-to-face collaboration, supporting traditional content learning and encouraging the development of communication and collaboration skills.

Eduinnova is built around activities specially designed for WI-FI enabled personal digital assistants (PDAs). A set of PDAs is contained in a mobile computer laboratory that can be shared between classrooms using a specially designed suitcase for transporting the units and charging their batteries. Thus, the technology supplies one device to each of the participating students in their regular classroom. This ensures Eduinnova can offer a cost-effective solution providing a 1:1 environment in the classroom that bridges the digital divide within schools.

A PDA technological network is created to support collaborative interaction between students and integration with other educational resources (the social network), as depicted in Figure 2.

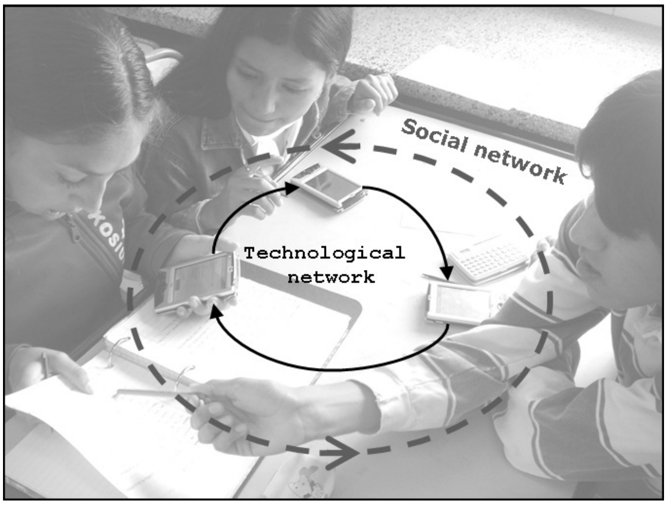

Figure 2: Technological network acts as a collaborative scaffolding for social interaction.

In this learning environment, students work in teams to solve problems sent to their PDAs by the teacher, who receives information back from the students' devices in real time on the performance of each team (Figure 3) and can thus monitor their progress and give advice (Figure 4e).

Figure 3: Teacher receives online information based on which advice can be given to lower-performing groups.

The dynamic of the Eduinnova system inside the classroom is as follows. The mobile lab is brought into the classroom, a PDA loaded with Eduinnova software is handed out to each student and the teacher creates a local network (Figure 4a). The software then randomly divides the students into groups of three (Figure 4b). The teacher selects an MCSCL activity involving a set of problems and sends it through the wireless network to the students, who set to work on solving the problems collaboratively. Each student has only some of the components needed for the solution, and must coordinate with her/his groupmates through face-to-face discussion on what component should be used and when. As an example, a group might have to build a sequence of numbers (Figure 4c) in which Student 2 puts the number 4 in first position, Student 3 puts the number 5 in second position and Student 1 puts the number 6 in third position. Once they have completed these tasks, the system sends them feedback on the result.

While the groups work on the activity, the teacher monitors their performance in real time through a color-coded matrix displayed on his or her PDA (Figure 3 and Figure 4d), in which the rows correspond to the groups and the columns represent the problems. The different colors indicate how many attempts the students made before solving a given problem. Thus, green means a problem was solved on the first try, yellow means it was solved on the second try and red means either that it was solved on the third try or not at all, depending on the problem structure. Based on this information the teacher assists the groups either individually (Figure 4e) or, if a number of them are struggling with a particular problem, the entire class.

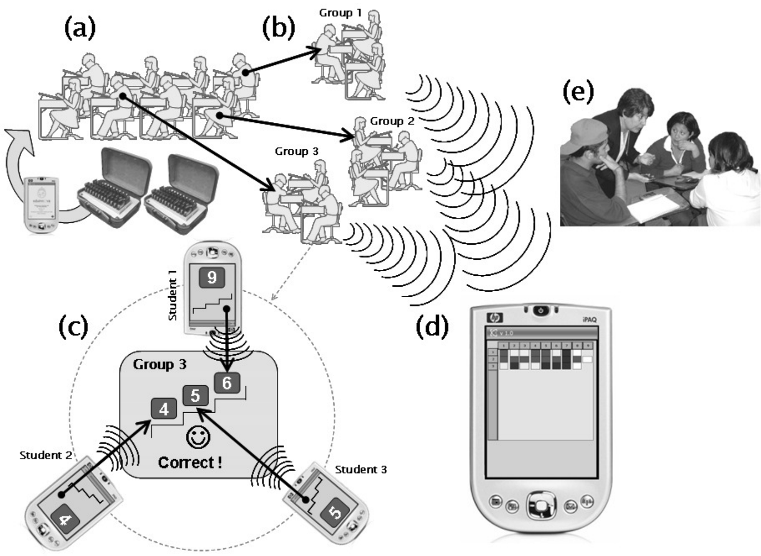

Figure 4: Inside the classroom, a collaborative environment is created by WI-FI enabled PDAs acting as seamless learning tools.

Perhaps one of the most important contributions of the Eduinnova program is that it not only offers a new model for ICT use in the classroom but also promotes new learning dynamics. The interactions supported by the software allow changes to be made in the interaction patterns between pupils, teacher and technology, accompanied by a change in, or modification of, the role of the teacher from 'expert' to facilitator, mediator and guide (Condie et al., 2006).

To effectively apply this ICT-supported pedagogical model, teachers must acquire certain technical skills for using the Eduinnova environment as well as the pedagogical skills to create new activities or select existing ones from an online library within a curricular framework that will encourage collaboration and learning in a specific subject to be taught. Most importantly, they need to know how to adequately mediate and support collaborative learning. In addition, using the mobile laboratory involves defining objectives for applying the ICT4E program (*e.g.*, improving mathematics learning in 4^{th} grade), lesson planning (*e.g.,* what content is to be covered in 4^{th} grade mathematics and when) and attention to the logistics of keeping the PDA batteries charged and sharing the lab among the different classes. All of these requirements must be enacted correctly in order for the technology to have an impact on student attainment.

Over the last three years the Eduinnova program has been extensively tested in Chile. It has been used in different grades and subjects in primary schools (Zurita and Nussbaum, 2004a, 2004b, 2007; Zurita et al., 2005), secondary schools (Cortez et al., 2005) and university settings (Bustos and Nussbaum, 2009; Valdivia and Nussbaum, 2009), in all three cases demonstrating a positive impact on student learning. The system has also been successfully utilized to help teachers update their knowledge of curricular content and exchange information on methodological strategies (Cortez et al., 2005). Similar results have also been obtained at schools in Argentina, Brazil, United Kingdom (Nussbaum et al., 2009) and the United States (Roschelle, et al., 2009).

The components of the monitoring and evaluation scheme

Previous to illustrate the specifics of these indicators we briefly describe an Eduinnova intervention for developing teacher autonomy without the support of an M&E scheme. The intervention was executed, mediated and supported by a project coordinator, professionals who coached teachers inside the classroom (classroom support) and technicians who supported school ICT staff (technical support). The intervention took place over 2 years and was divided into 4 main phases: introduction, training and coaching, remote supervision and autonomous implementation. Details of the phases and their duration are set out in Table 1.

Table 1: Phases of Eduinnova intervention on schools.

Year	Phase	Main activities	Duration (weeks)
One	Introduction	• Introduction of intervention to school staff. • Supporting adaptation of the pedagogical model to school context and objectives for ICT integration: subjects and grades. • Assessment of students' attainment in achieving school objectives.	3
	Training and coaching	• Training teachers and ICT staff. • Coaching teachers inside the classroom, providing them feedback about the pedagogical model and ICT integration. • Classroom observations to assess teachers' adoption of pedagogical model. • On-site and remote technical support of school ICT staff.	14
	Remote supervision	• On-site and remote technical support of school ICT staff. • Assessment of students' attainment in achieving school objectives.	16
Two	Autonomous implementation	• On-site and remote technical support of school ICT staff. • Assessment of students' attainment in achieving school objectives..	36

An M&E scheme was defined for Eduinnova using the concepts introduced in previous sections. In what follows, we present the scheme's input and process indicators, outcomes, assessment instruments and monitoring plan.

Input indicators

The input indicators were defined on the basis of previous experience. They match the phenomena reported in the literature as factors influencing ICT introduction in schools. These factors are:

- *Teachers' ICT skills* (Pelgrum, 2001; Conlon and Simpson, 2003; Reynolds et al., 2003; Hayes, 2007).
- *A school's ICT infrastructure* (Pelgrum, 2001; Conlon and Simpson, 2003; Reynolds et al., 2003).

- *Supervision and technical support* (Pelgrum, 2001; Conlon and Simpson, 2003; Hayes, 2007).
- *Involvement and leadership of school principals* (Pelgrum, 2001; Hayes, 2007).
- *Time spent by teachers on meetings, training, exercises and lesson planning* (Conlon and Simpson, 2003).

Process indicators

For each phase of the intervention shown in Table 1, indicators associated with each activity were defined. They provide a detailed vision of the work performed by the professionals responsible for the intervention.

Intervention indicators

These indicators represent milestones in the intervention process. Once they have been reached, certain adoption indicators can be assessed. As an example, the intervention indicators for the training and coaching phase are given below together with their respective milestone criteria:

- *Teacher training in structuring lessons using ICT*: refers to training in basic software use skills both in technical and pedagogical aspects at the start of implementation (milestone: attendance by 80% of teachers).
- *Workshop on MCSCL for teachers*: deals with practical application of ICT for collaborative learning support (milestone: attendance by 80% of teachers).
- *Workshop on integrating ICT into the classroom*: addresses how to integrate ICT with other digital or non-digital resources and the timing and objectives for using ICT in a lesson (milestone: attendance by 80% of teachers).
- *Teacher training in developing their own content for MCSCL* activities: consists of training in use of the Eduinnova system to create MCSCL activities (milestone: attendance by 80% of teachers).
- *Observations and support of each teacher's first lesson using PDAs*: classroom observations to support teachers on ICT implementation, reinforcing content of initial training (milestone: 80% of teachers supported)

The intervention indicators allow adjustments to be made to the actual application of the monitoring plan for adoption indicators. For example, there would be no sense in assessing teacher adoption of a pedagogical model if the necessary training were not yet complete.

Adoption indicators

The adoption indicators monitor three objectives: 1) development of school actors' skills, 2) proper enacting of main features of the ICT4E in classroom, 3) persistence over time of the conditions established at the beginning of the intervention as measured by input indicators to ensure implementation sustainability.

In terms of our example, the first objective is illustrated by indicators developed for evaluating teacher adoption during the training and coaching phase. These indicators assess the development of skills for proper implementation of the pedagogical model and using technology in the classroom without external support. In specific terms, the indicators for this phase are:

- *Teachers' technical skills*.
- *Integration of ICT within the curriculum*: quality of integration of MCSCL activities within a class in accordance with its objectives, taking into account appropriate timing considerations and the resources (digital or non-digital) involved.
- *ICT management inside the classroom*: efficiency of technical setup and use of classroom time.
- *Pedagogical skills in collaborative learning*: level of teacher's achievement in supporting, monitoring and providing feedback when students work collaboratively using the Eduinnova system.

Assessment instruments

The adoption indicators just described are evaluated using a single assessment instrument known as an *observation protocol*. The observer assigns values to the various dimensions defined under each indicator using the instrument's *rubrics*. For instance, in the case of the "pedagogical skills in collaborative learning" indicator, the teacher is assigned values on four dimensions: support of group discussions, group supervision, providing feedback on results, completion of MCSCL activity and integration of MCSCL activity within the lesson. The rubric for support of group discussions is the following:

- *Basic level*: teacher provides no support to the groups, or only to a few.
- *Medium level*: teacher only resolves issues and answers questions directly, without motivating students to think for themselves or debate.

➢ *Advanced level*: teacher provides support, giving examples to students or integrating content covered in previous lessons and motivating students to discuss.

Observers must be previously trained to unify their criteria when applying this instrument in order to ensure comparability among teachers and schools. Such training will usually involve observing a classroom in the presence of a senior professional.

Using the observation protocol, the adoption indicators can be expressed in quantitative terms as an achievement percentage based on the total protocol score.

Monitoring plan

The expected evolution of the adoption indicators can be established on the basis of the corresponding assessment instruments and previous experience. The intervention indicators determine when each adoption indicator is to be assessed.

Below we present an example of a monitoring plan and the expected evolution of two of the above-described adoption indicators, “ICT management inside the classroom” and “pedagogical skills in collaborative learning.” The evolution of these indicators in terms of expected achievement for a group of teachers participating in the intervention is depicted in Figure 5, which illustrates how the designers’ experience acquired during previous Eduinnova interventions can be specified declaratively.

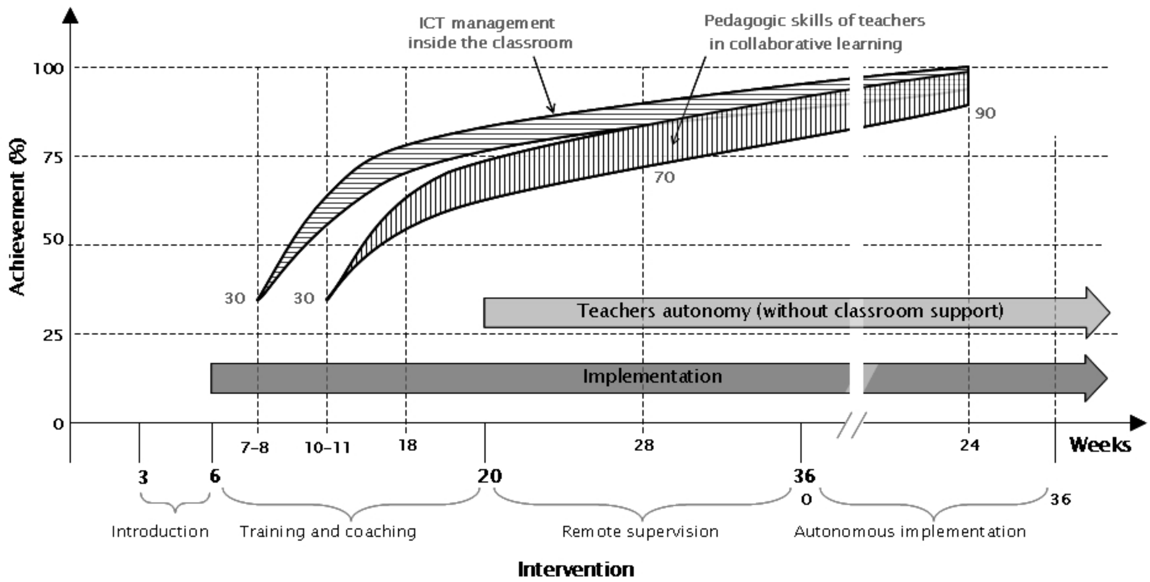

Figure 5: Expected evolution of two indicators according to designer team’s experience.

The timeline in the figure represents the phases defined in Table 1. The adoption of ICT skills commences once “teacher training in structuring lessons using ICT” (see Intervention indicators section) is complete (around the 7th or 8th week). The adoption of pedagogical skills begins when the “workshop on MCSCL for teachers” ends, around the 10th or 11th week of intervention. Between the 10th and 18th week, teachers are visited in their classrooms by the pedagogical support personnel who coached them in the effective use of the Eduinnova tool. Each teacher is visited at least 2 or 3 times and assessed using the observation protocol described earlier.

By the 18th week, all teachers should have reached a performance level of 60% in pedagogical skills and 70% in ICT skills. Around the 20th week, the remote supervision phase begins and external support ceases to encourage autonomy in schools and reduce intervention costs.

Outcomes

There are three expected outcomes of intervention and implementation processes: 1) the effective adoption by teachers of technology in their lessons to support teaching/learning processes; 2) student attainment improvements in subjects that apply the ICT4E program; and 3) achievement of school autonomy in the management of the program.

Since adoption indicators have already been defined, outcomes can be expressed in terms of the values they attain. For instance, the development of teachers' ICT and pedagogical skills can be expressed in terms of the levels of adoption indicators "ICT management inside the classroom" and "pedagogical skills in collaborative learning." From previous experience, we expect the two indicators to reach 90% and 95% respectively by the end of a two-year intervention.

In regard to student attainment, an effect size (Cohen, 1998) greater than 0.25 (Agodini et al., 2003) can be expected for a quasi-experimental design with pre- and post-tests applied to project and control populations. The control populations may be students at the same school (internal control group) or students with similar characteristics at schools of the same stakeholder (external control group). The type of comparison and experimental design should be decided at the beginning of the ICT4E program implementation.

Validation of the proposed M&E scheme

The main motivation for developing an M&E scheme to Eduinnova, was we observed that the final levels of adoption reached differed from one teacher to another after intervention. This variation naturally raises questions regarding the relationship between teacher adoption levels and program effectiveness in terms of the impact on student attainment. The implementation of an M&E scheme provided the answers.

In 2005-2006, the Eduinnova program was implemented at five schools located in the Chilean cities of Santiago (3) and Antofagasta (2). The participant schools were all public or private, but state-funded establishments serving students from the lower-middle socioeconomic strata, with general relatively poor results and with no other external educational interventions.

The objective was to support the learning of 10th grade physics course content. A quasi-experimental design was employed using experimental (EG) and internal control (ICG) groups. At each school, different sections of the course given by a single teacher were randomly assigned to one or other of the two groups. Students in the EG group used the technology while those in the ICG group were taught in the traditional lecture format. The impact on students at two schools (one in each city) with similar socioeconomic, funding source, average scores on Chilean national standard assessment tests (SIMCE) and social vulnerability index characteristics was also evaluated (external control group or ECG) to compare results within a no project context. Table 4 shows the data corresponding to these groups. With the adoption of this design, we expected to be able to measure the net impact of the ICT4E on student attainment by applying tests before and after the treatment and comparing the performance levels of the two groups.

Table 2: Characteristics of each group in the experience.

Group	Number of courses		Total courses	Total students
	Santiago	Antofagasta		
Experimental (EG)	4	5	9	480
Internal Control (ICG)	2	3	5	320
External Control (ECG)	2	2	4	160
Total	8	10	18	960

Impact on student attainment

The students' attainment in physics was measured by a test developed by the Eduinnova program team containing 31 multiple-choice questions, with 5 options each. The test was validated with a different population from experiment (*N=153*), showing an average difficult of *0.48* and high internal consistency (Cronbach's $\alpha=0.87$).

The test was given twice: once before implementation (pre-test,) and again at the end of the school year (post-test) approximately eight months later , y en ambos casos aplicado por el equipo de Eduinnova, sin que los profesores y alumnus tuvieran acceso a las pruebas antes y después de su aplicación. Adicionalmente, ningún estudiante recibió feedback de sus resultados obtenidos en el pre-test. The results for each test are expressed as achievement percentage (raw obtained score per student divided by the total number of test questions).

The analysis between groups were performed on net improvement per student, to prevent any practice effect on post-test, and all the groups were exposed to pre-test. Despite that, Welch and Walberg (1970) suggest that the pretest alone does not lead to significantly higher post-tests when the treatment duration is as long as seven months.

The improvement was calculated as the percentage advancement of each student, *i.e.*, the difference between post- and pre-test achievement per each student. Therefore, the analysis only considers population which answered both pre-and post-tests. The results are summarized in Table 3.

Table 3: Results of pre-, post-test and improvement for each group in experiment.

Group	N	Pre-test (%)		Post-test (%)		Improvement (%) [Difference between post-test and pre-test measured for each student]	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
EG	274	29.527	9.893	42.701	10.757	13.174	13.595
ICG	130	28.412	12.651	36.079	10.769	7.667	13.281
ECG	87	29.181	12.560	37.931	14.766	8.750	14.451

Note. The results obtained on post-test are consistent with the national performance of 8th graders on TIMSS, the international science test, in which Chile placed 37th out of 46 countries in 2003 (Martin et al., 2004).

The t-tests show there is not statistical differences between the three groups on pre-test. However, on the improvement indicated by comparison between EG-ICG, the t-test shows statistically significant differences (*t=3.864, p<0.000*) with an effect size of *0.41*. Also, the inter-group difference EG-ECG on improvement, is also statistically significant (*t=2.604, p<0.01*), with an effect size of *0.32*. Since the difference between ICG and ECG on improvement, is not statistically significant, we may assert that the impact revealed by these data are attributable to the technology. They also indicate that the program is highly effective given that effect sizes for ICT4Es are normally expected to range between 0.25 and 0.35 (Agodini et al., 2003; Dynarski et al., 2007).

Relationship between impact on learning and level of adoption of ICT-supported pedagogical model by teachers

During the implementation, the eight teachers involved were observed using an observation protocol (see section assessment instruments) in accordance with monitoring plan to determine whether they enacted the main features of the ICT-supported pedagogical model correctly. They were evaluated on four dimensions: *teachers' technical skills, integration of ICT within the curriculum, ICT management inside the classroom and pedagogical skills in collaborative learning* (see section adoption indicators).

The possible levels for each of the previously mentioned dimensions were low, medium and high, and a general *teacher adoption level* was calculated as the average of all four .At the end of the first year of implementation, five teachers had achieved a medium adoption level and only three reached a high level. The improvement in the experimental group by teacher adoption level is presented in Table 4.

Table 4: Results of experimental group by adoption level of teachers.

Teacher adoption level	N	Pre-test (%)		Post-test (%)		Improvement (%) [Difference between post-test and pre-test for each student]	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Medium	76	28.396	10.309	37.521	10.586	9.126	14.706
High	198	29.961	9.720	44.689	10.167	14.728	12.847

Again, t-test shows that there is not statistical difference for the two upper levels (medium and high) on pre-test. But, the difference for medium and high levels was found to be statistically significant on improvement (*t=3.102*, *p<0.05*). Thus, among the students who used the Eduinnova technology, those whose teacher had a greater adoption level obtained better results.

In addition, students in EG with high adoption level teachers ("EG-High") displayed a significantly stronger improvement than those in ICG *(t=4.804, p<0,000)*, with an effect size of *0.54*. The EG-High students did better than those in ECG as well, with an effect size in this case of *0.45 (t=3.480, p<0.001*). On the other hand, comparisons between EG-Medium and either of the two control groups on improvement reveal no statistically significant difference. Therefore, the main contribution to make statistical significant differences between EG and ICG and ECG come from the students with high adoption level teachers.

At this point we must ask whether these results are due to factors other than the Eduinnova technology, and in particular, to the performance of the teachers independently of their use of Eduinnova. In anticipation of this, teacher performance was measured before the implementation of the ICT4E by evaluating a class without PDAs on the basis of 13 items regarding class structure, activity management, type of participation generated, classroom climate, student supervision and behavior management. The responses were scored per item on a scale of 1 to 5, with 5 indicating the best performance level.

Given the high internal consistency obtained on this scale (Cronbach's $\alpha=0.95$), it was decided to use the average of these item scores as an indicator of the teacher's general performance.

A covariance analysis in which levels of teacher performance were the covariables concluded that this factor was not significant as a predictor of the students' percentage improvement ($p=0.155$). On the other hand, the group factor was found to be significant ($p=0.000$). An experimental intragroup analysis revealed that there were no statistically significant differences in student improvement attributable to teacher performance, whereas such differences did occur for teacher adoption of the technology.

Therefore, as it was designed, monitoring and evaluation of the adoption indicators defined is critical for a successful implementation of this specific ICT4E program. Additionally, this experience demonstrated that the adoption indicators were well-defined since there is a direct relationship between lower level of adoption and lower levels on students' attainment.

Conclusions and future work

This paper presented a series of concepts for the creation of a monitoring and evaluation (M&E) scheme to assess the fidelity of implementation of ICT4E programs. A specific M&E application scheme was then developed for a program known as Eduinnova. .

An M&E scheme is a basic component in the implementation of any educational program, whether or not it is supported by technology. Its principal aim must be to effectively measure the development of the skills of all involved actors in order to correctly establish the degree to which the program has been successfully adopted.

To fulfill this purpose it was necessary to conceptualize the ICT4E beforehand in order to determine clearly what was important or critical for teachers to enact in their classrooms and develop measures for determining whether and how those features were being performed in real classrooms (Penuel, 2005). Had this not been done it would have been impossible to develop evaluation instruments for measuring phenomena such as teacher adoption.

En el caso presentado aquí, los resultados de impacto en el aprendizaje de los alumnos corroboran que existen efectivamente cuatro dimensiones críticas (teachers' technical skills, integration of ICT within the curriculum, ICT management inside the classroom and pedagogical skills in collaborative learning), que los profesores deben manejar adecuadamente para que Eduinnova sea efectiva. Además que estas no están relacionadas con el desempeño previo del profesor. Esto valida el esquema de M&E propuesto y apoya con evidencia que the impact on student attainment depends on how the teacher selects and organizes ICT resources and how their use is integrated into other activities in the classroom and beyond (Cox and Marshall, 2007).

Therefore, an M&E scheme supports the intervention process by providing real-time information for allowing to adjust intervention activities so that an adequate level of adoption is assured where this was not previously the case. As a result, in the case presented here, remedial actions were performed at the second year of implementation at Santiago and Antofagasta. Additionally, these actions were incorporated as a standard part of the intervention, based on common weakness detected by the M&E scheme

Finally, an M&E scheme also allow to understand what really happen with ICT4E program implementation in real world conditions. This is extremely important, since several studies which assessed impact of ICT on education only can say if the impact there exists (Watson, 1993; Harrison et al., 2002) or not (Dynarsky et al., 2007; Campuzano et al., 2009), but they did not provide information about why they are or not effective. Systematic information from an M&E scheme can provide the answers.

As regards future research, there are at least two areas in which further work is needed to improve the developed M&E scheme: 1) the correlations between the intervention and adoption indicators to eliminate any redundant ones, thus lowering the cost of indicator measurement; 2) the correlation between the M&E indicators and student attainment. The latter topic is particularly interesting because the correlation between the adoption indicators and student attainment enables calculations to be made of the marginal benefit of improving teacher skill adoption and thus determine an optimal level of teacher training and coaching and 3) the development of an information system to support an M&E scheme furnishes the tools to store all data and construir las curvas reales de variabilidad de los indicadores (as it is depicted in Figures 1 and 5), y cómo estas cambian entre distintas intervenciones para construir perfiles de distintas intervenciones según las características de los colegios.

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