An Assessment Information System for a K-12 Hands-On Program: The *Pequeños Científicos* Case

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Abstract **– The assessment and evaluation of educative initiatives are often characterized by lack of organization, which is probably due to the multilevel nature of the educational phenomenon. We encounter this situation in *Pequeños Científicos* (Little Scientists), a Colombian program in active learning for pre-college science and engineering education, on top of other difficulties related to changes in schools, teachers, children, and management systems. In this paper we present a brief overview of the rationale behind the assessment system we chose for this program. We focus on a management system that allows monitoring and feedback to different actors and levels involved in this initiative. This process and an analysis of its results are presented in terms of coverage, consolidation and quality. *Pequeños Científicos* introduces another way to do Engineering in Education, going beyond the analysis of generalities or global visions, and taking into account little scientists and their environment (interpersonal-educational-psychological).**

Key Words- Management Information System, Pre-College Engineering Program, Pequeños Científicos, Assessment, Evaluation.

K-12 LITTLE SCIENTIST PROGRAM

Pequeños Científicos (Little Scientists) is one of the programs of the School of Engineering at Universidad de Los Andes in Bogotá, Colombia [1, 2]. For its implementation, a strategic alliance has been created with the Maloka science museum, Bogotá's French Lycée Louis Pasteur, the Colombian Science Academy and Alianza Educativa (the association in charge of Bogotá public schools). The four institutions have subscribed to a cooperation agreement that supports the program's implementation strategy.

As a program, *Pequeños Científicos* belongs to the K-20 strategy (the engineering of learning, the learning of engineering), devised by the School of Engineering with the purpose of creating a continuum of educational levels—from Kindergarten to Doctorate— specifically focused on the teaching/learning science, technology, and engineering. The evaluation of this program has been supported by LIDIE (Laboratory for Research and Development in Engineering Education).

Pequeños Científicos aims to renew the learning process in the field of experimental sciences and technology at the elementary level. Through observation, manipulation, confrontation, discussion, and problem solving, this project promotes a new level child involvement in science and technology since a very early stage in their educational process.

This project has been articulated to the work of similar research and development groups around the world, which work with IAP (Inter Academy Panel). In particular, besides sustaining exchange and cooperation agreements with more than ten countries, *Pequeños Científicos* keeps a close working relationship with teams in the United States (EDC, Caltech) and France (INRP- Science Academy La main à la pâté).

As a program, *Pequeños Científicos* has the mission of promoting and contributing to the renovation of science and technology learning in Colombia. Such renovation seeks to introduce a guided inquiry process in the classroom, in a cooperative learning atmosphere aiming at the students' construction of their own scientific skills. At the same time, the strategy seeks to enhance the development of communication abilities and the strengthening of values associated with citizenship.

A FRAMEWORK: SCIENTIFIC AND TECHNOLOGICAL LITERACY TROUGH INQUIRY

Recent declarations and statements from different institutions and organizations stress the importance of scientific and technological literacy for all citizens[3]:

> Scientific literacy is also increasingly important in the workplace. More and more jobs require that people be prepared to think critically, solve problems, and use technology effectively. Furthermore, we need a scientifically literate public if we are to compete successfully in the global marketplace.

Particularly, some of those declarations point to engineering and mathematics schools involved in STEM

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(Science, Technology, Engineering and Mathematics) initiatives[4]:

> The challenges to STEM educators in the 21st Century will be to …. aim for a level of education in STEM so that all members of society can make sensible decisions and choices in areas of their lives that impinge on scientific discovery and application and ensure that the power bestowed on humankind by S&T is used for the benefit of all and not the few.

This reference also mentions that:

> Sustainable development depends on a scientifically and technologically literate population.

In [3] it is stated that:

> *Scientists and engineers* from college and university faculties, industry, government laboratories, and science museums have a special interest in the scientific literacy of the next generation. They can help with the reform effort in many different ways, including assisting in professional development programs for teachers, reviewing curriculum materials, and becoming community advocates for the program.

Finally, UNESCO indicated in 1990[5]:

> The **World Declaration on Education for All** arising from the international meeting in Jomtien (Thailand, 1990) stressed that sustainable development depends on a scientifically and technologically literate population. Governments and public and private sector interest groups were urged to review educational provision for achieving STL for all.

Thus, scientific and technological literacy is important it promotes:

- Competitiveness and sustainable development.
- Citizen inclusion and participation in a technological society.
- Participation in societal decisions concerning science and technology.

On the other hand, Inquiry-Based Science Education (IBSE) has become a privileged teaching-learning strategy supported by Science Academies of the World. Its basic principles can be presented in the following terms[6]:

> Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations. Students will engage in selected aspects of inquiry as they learn the scientific way of knowing the natural world, but they also should develop the capacity to conduct complete inquiries.

The assessment of any novel educational strategy obviously becomes a very important issue. Scientific thinking acquisition is not easy to evaluate. In recent years assessments of IBSE programs began to appear, showing potentialities and difficulties [7, 8].

ORGANIZING A NATIONAL PROJECT

A nation-wide project such as *Pequeños Científicos*, which involves teacher education, follow-up, logistics, and continuous evaluation, requires an appropriate organization. The project has initiated the implementation of a structure, which, while ensuring quality and accordance to the program's principles, allows for an efficient and solid management.

The structure is based on the configuration of a "Central Nucleus", responsible for the project's general conception, its evaluation scheme, innovation control, teacher education, and the construction of "Regional Poles." These, in turn, guarantee commitment, continuity, and quality in the regional sphere.

The following graphic illustrates the organizational structure of the Pequeños Científicos Program.

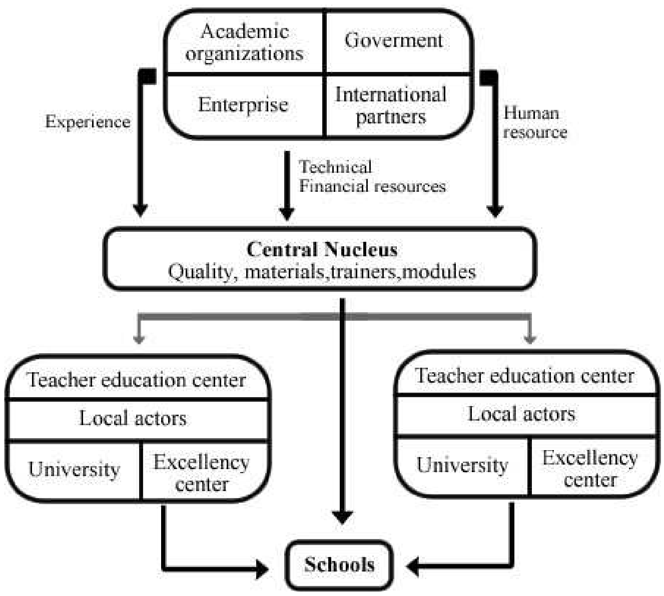


FIGURE 1
ILLUSTRATES THE ORGANIZATIONAL STRUCTURE

PROBLEM DESCRIPTION AND SOLUTION

In a framework such as the one described for the national implementation of the program, assessing the practices performed by the various actors becomes a fundamental issue. Feedback is also very important. Building a complete picture of the processes and results of the program requires the retrieval of information from different regions, schools, classrooms, teachers and children. These sources of information are needed in order to maintain the standards of the program, while providing reliable information for decision making at different levels. On the other hand, only a careful processing of this information will generate valuable and useful feedback at all levels.

At the same time, given the proportions of the program and its goals in coverage growth, it is important that an evaluation system considers different variables related to the levels of region, school, teacher, classroom and children. Under this rationale, the evaluation system created for *Pequeños Científicos* focuses on the follow-up and feedback of the activities to which children and youngsters are exposed. Questions such as the following have to be answered in order to evaluate the program: How many schools, teachers and children are in the program? Do teachers have institutional support? Is the curriculum based on inquiry or does it use inquiry as a complement? For how many years has a particular child been involved in the program? Is the science classroom atmosphere providing the appropriate support for child development?

FIGURE 2
ORGANIZATION OF THE EVALUATION SYSTEM OF THE PEQUEÑOS CIENTÍFICOS PROGRAM

In order to answer these questions an evaluation system based on the structure presented in figure 2 was adopted. The core dimensions of this system are: 1) Quality, focusing on the process and results of student learning, teacher practices and organizational structure of the school and the region, 2) Degree of Consolidation, of both the organizational features of the institutions and the required conditions for the growth of the program after the training stage, and 3) Coverage, by which the national program keeps track of its participants.

The Assessment Information System operates from the inception of a training process for a group of new schools willing to participate in the program. Once they express their intentions to participate, demographic data are collected about their organizational characteristics, the teachers that will participate, and finally the students that will be exposed to the program,

During the training of teachers and their simultaneous implementation of the strategy in their classrooms, there are numerous moments where the program gathers data about the coverage and consolidation of the school or region, in order to create a census of its participants. Once all the demographic data are gathered, statistical representative samples are drawn to select a group of children, classes, teachers and schools, from where the quality data will be collected on a pre-test, post-test basis. Also, during the implementation phase in a particular school, consolidation data are gathered to establish relationships between the implemented changes at the institutional level and the observed changes both in the classroom and in the learning process. Over a complete academic year, the evaluation system gathers and analyzes data from different variables and different levels of implementation. Once analyzed, data return to the teachers and institutions in training, in order to support individual reflection processes pertaining to their own results. Also, at the end of the academic year, data concerning the development of a whole region are consolidated and revised with the teachers, principals, and researchers. The outcome of these activities may determine the need to involve both teachers and administrators in strategic planning workshops in which, practices and directives introduced during the analyzed period are examined and discussed in relation to perceived changes on different variables at the assessed levels.

With the purpose of accompanying this system, an integrated tool for the management of information has been recently developed. This tool captures, stores, and processes data related to the core dimensions of the assessment system. It also contributes to diminishing the delay between the collection of information and the effective delivery of feedback to the actors.

According to this evaluation framework the first assessment information system was implemented in 2006. In the following sections the features of an information system are presented.

PLATFORM CONCEPTION & SYSTEM SOLUTION

The assessment information system emerges from the need to present reports to the different actors involved in the program's development in a timely and reliable manner.

In view of our program's needs, we developed this system in order to support analysis and improve feedback time. Since the assessment system is continually evolving, one of the prominent features of our information system design is its flexibility and adaptability

I. Platform definition

The information system is designed as a website that stores and processes data. Figure 3 shows the architecture of the system:

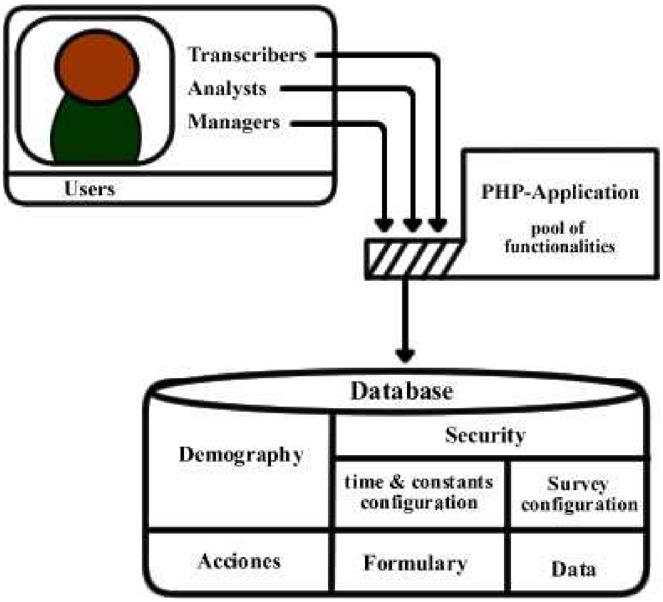


FIGURE 3
SYSTEM ARCHITECTURE

The main characteristics of our system are:

- A kernel of the information system (a data base in a web service) that facilitates the accessibility and flexibility for future developments.
- A design that follows the structure of our assessment system: Demography (Actors at the different levels), Actions (quality, coverage) , and Time,
- A set of instruments and procedures meant to collect and validate data .
- A set of basic analysis procedures to build the main set of reports of the assessment system.
- A friendly interface adapted to different user profiles.

II. Model design

The flexibility required to follow the program´s assessment system evolution is provided by the modular design of the database. The database presented in figure 3 is based on the abstract organization presented in figure 4:

- Actors of the environment (schools, teachers and children)
- Evaluation dimensions (quality, coverage and consolidation)
- Time (considered as a dimension for chronological purposes).

These dimensions are present in the evaluation system organization (Figure 2).

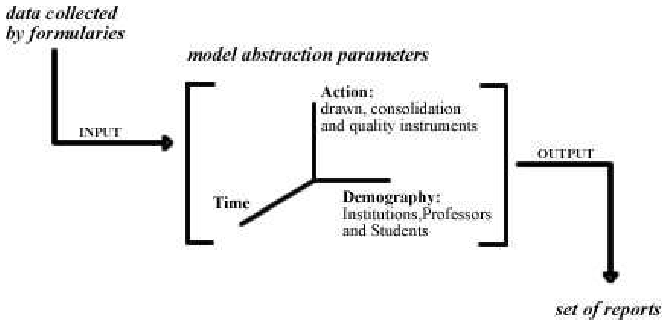


FIGURE 4
MODEL ABSTRACTION

Two classes of instruments were designed to collect and validate data:

- Demographic: focused on actual data of actors. A clear case of this is form F-EVA-03 that allows the registration of classes in the program. This form asks for teacher´s name, students and modules used in the period of time asked.
- Activities: focused on data concerning the actions performed by actors of the program. The main characteristic of this class is the existence of tests or polls. The tool allows previous configuration of question items in the test. In this way the system supports several applications of it on a sample, and to create indicators for the analysis task.

Outputs of the information system are reduced to a simple request on a database. That means: a report only consults the state of an actor and its indicators resulting from polls in itself.

Another relevant feature is the visualization tool based on web forms or XLS files. XLS allows for more data and can be compared to different elements at the same time. Choosing an option depends of analyst`s requirements. For example administrators prefer small reports with the most relevant information, and statistical analysts need a matrix of indicators over all demography variables.

III. Utilization and administration features

To this time, the implementation of the Assessment Information System has allowed the national program to collect, store, relate, analyze and feedback the whole process following a procedure that can be summarized in the following steps:

- Demographic data is collected on a yearly census basis through enrollment instruments for institutions, schools, teachers and classes.
- Once the population of the program has been actualized, different representative samples are drawn and consolidation and quality instruments are sent to schools, teachers and classes.
- Finally, results from the preceding phases are organized on the coverage, consolidation and quality dimensions in order to produce the reports for a region, school class summarized for each level.

Relating to the management of the accessibility to the tool, Users are classified into 3 general groups:

- Transcribers (those in charge to feed the tool with the collected information,)
- Analysts (those in charge of evaluating the performance of the system)
- Managers (who are I charge of the configuration of the variables and the users clearance on the system.).

This rank of users allows to store all the information collected and to calculate the needed dimensions to evaluate the Pequeños Científicos program.

The roles and functionalities mentioned have been configured to use a security protocol that assures the reliability of the stored information. By this, the use of the application is restricted to some tasks according to the role and assuring the integrity of the information.

This goal is achieved with the implementation of a kernel, which controls privileges of user over functionalities.

A Processing module, a security protocol and a template web design are the three independent software modules. This implementation allows changes in one of these without change the others. For example, the style of the website doesn't affect rest of the source code.

The processing module includes functions corresponding to every requirement of the assessment system. That does include: management of institutions, course, teachers, visits, quality evaluations and growth reports, among others.

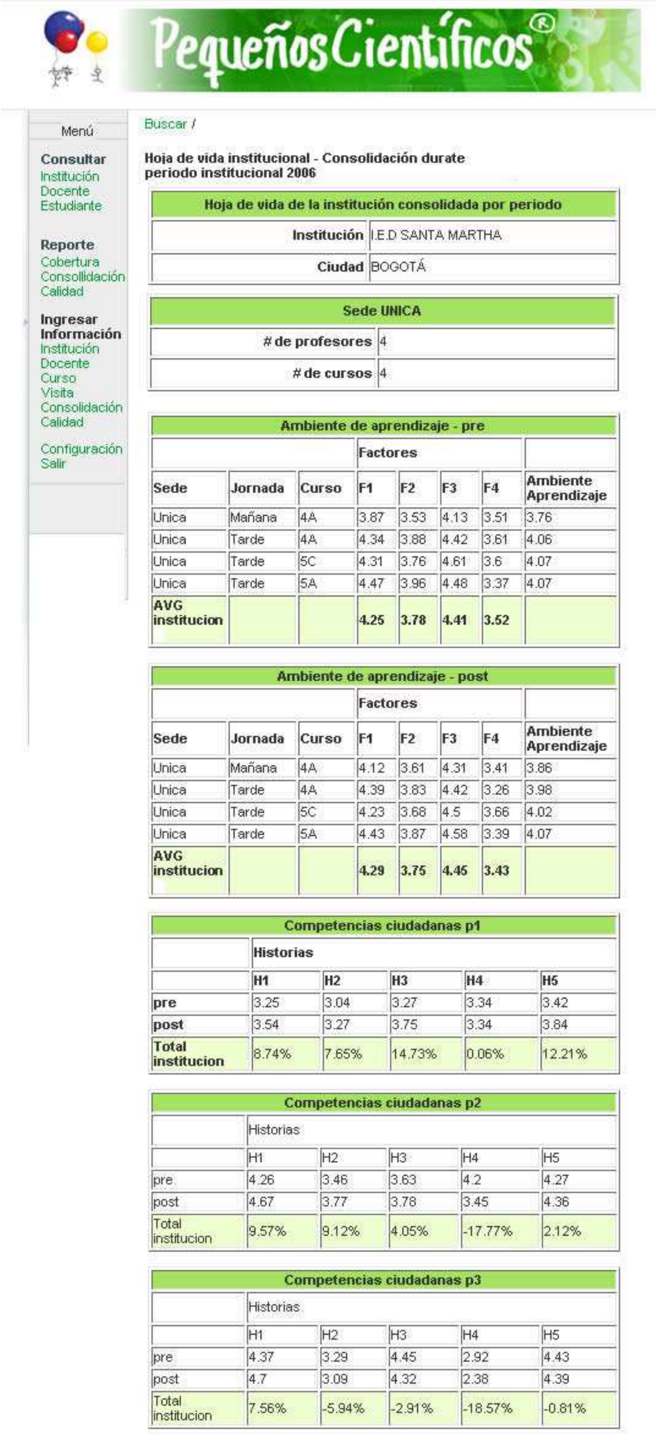
The information system design, the strategy of implementation and the quality of documentation are the basis to ensure the evolution of the system as consequence of evolutions on the education practices and evaluation process.

INSIGHTS INTO THE INFORMATION MANAGEMENT TOOL

The experience of development and implementation of an information system for the Pequeños Científicos Program have showed preliminary but promising results. To this date, the number of actors involved in the program make necessary to manage the information in order to take accurate and timed decisions over the actions and processes it develops.

The general evaluation system together with the Assessment Information System has provided the program with an important tool for feedback around coverage, consolidation and quality of its different actions.

To this date, the functionalities and potentialities of the information system have been only explored. Obtained results are promising to a program for scientific literacy development (Figure 5). This project and its future implementation on a larger scale, shows another argument to think in the role of the engineering in the education and the education on engineering.



Hoja de vida institucional - Consolidación durate periodo institucional 2006

Hoja de vida de la institución consolidada por periodo	
Institución	I.E.D SANTA MARTHA
Ciudad	BOGOTÁ

Sede UNICA	
# de profesores	4
# de cursos	4

Ambiente de aprendizaje - pre

			Factores				
Sede	Jornada	Curso	F1	F2	F3	F4	Ambiente Aprendizaje
Unica	Mañana	4A	3.87	3.53	4.13	3.51	3.76
Unica	Tarde	4A	4.34	3.88	4.42	3.61	4.06
Unica	Tarde	5C	4.31	3.76	4.61	3.6	4.07
Unica	Tarde	5A	4.47	3.96	4.48	3.37	4.07
AVG institucion			4.25	3.78	4.41	3.52	

Ambiente de aprendizaje - post

			Factores				
Sede	Jornada	Curso	F1	F2	F3	F4	Ambiente Aprendizaje
Unica	Mañana	4A	4.12	3.61	4.31	3.41	3.86
Unica	Tarde	4A	4.39	3.83	4.42	3.26	3.98
Unica	Tarde	5C	4.23	3.68	4.5	3.66	4.02
Unica	Tarde	5A	4.43	3.87	4.58	3.39	4.07
AVG institucion			4.29	3.75	4.45	3.43	

Competencias ciudadanas p1

	Historias				
	H1	H2	H3	H4	H5
pre	3.25	3.04	3.27	3.34	3.42
post	3.54	3.27	3.75	3.34	3.84
Total institucion	8.74%	7.65%	14.73%	0.06%	12.21%

Competencias ciudadanas p2

	Historias				
	H1	H2	H3	H4	H5
pre	4.26	3.46	3.63	4.2	4.27
post	4.67	3.77	3.78	3.45	4.36
Total institucion	9.57%	9.12%	4.05%	-17.77%	2.12%

Competencias ciudadanas p3

	Historias				
	H1	H2	H3	H4	H5
pre	4.37	3.29	4.45	2.92	4.43
post	4.7	3.09	4.32	2.38	4.39
Total institucion	7.56%	-5.94%	-2.91%	-18.57%	-0.81%

FIGURE 5
MANAGEMENT INFORMATION SYSTEM INTERFACE
INSTITUTION QUALITY REPORT

WORKING TEAM

The development of this system is the product of an interdisciplinary team involving scientists, engineers, mathematicians and psychologist. Sincere gratitude to all team member who made this project possible.

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