Inquiry based science education and its impact on school improvement: The ECBI Program in Chile

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Introduction

In spite of the extraordinary advances of science and technology in the last decades and the increase of their influence, science continues to be a site of privileged knowledge. There is consensus at different levels that the achievement of a more equitable access to scientific knowledge, requires improving the quality of science education in schools. Envisioning that this challenge cannot be confronted by the school system alone, the World Science Academies have called for "a stronger involvement of scientists to work as active partners with their local educational systems to ensure effective science education" (InterAcademy Panel of World Science Academies, 2000). This new deal between science and schools has a great potential to induce the changes that are required to improve the quality and equity of education. In Chile, the Chilean Academy of Sciences has encouraged the establishment of an "Inquiry-Based Science Education Program (ECBI, Spanish acronym)" a joint initiative of the Chilean Academy of Sciences, the Ministry of Education and the Faculty of Medicine of the University of Chile.

The program is inspired by the belief that high quality science education is important for all children. Effective science education is expected not only to expand children's understanding of the natural and material world, but also to stimulate their curiosity, introduce them to the practice of scientific inquiry and prepare them for lifelong learning. It is anticipated also that effective science education will contribute to the full expression of children's creative potential, improving their quality of life and that of their community.

The implementation strategy of the program, which is the subject of this paper, is systemic and it follows the model developed by the National Sciences Resources Center (National Academies and Smithsonian Institution). It includes five different components: curriculum, professional

development, material resources, community support and assessment. Cooperation and leadership is considered essential to ensure real and sustainable change and thus, a major effort is devoted to the strengthening of interactions inside and outside the school system by working together with a common goal in view.

The program, which initially was aimed exclusively at developing a model for improving science education in Chilean elementary schools, is now producing changes that exceed its original goals and which are encouraging new forms of relationship between the different individuals and organizations that constitute the system. We suggest that this is due to the fact that the attitudes that are inherent to inquiry, and which are therefore fostered and strengthened by the practice of the approach, lead to productive and fruitful interactions that are guided by cooperation, creativity, self-evaluation, critical reflection and a strong ethical behavior.

During the last decade the concerns for equity and quality that oriented the Chilean Education Reform resulted in important structural changes. Among the most relevant are a national curriculum framework that sets the Minimum Contents and Key Objectives for learning; syllabuses for all subjects matters in all levels; building of new schools and classrooms in view of the extension-of-the-school-day from half- to full-day (232 more hours/year in primary schools); increased connectivity through the introduction of an extended ICT system; a massive program to familiarize teachers with the new curriculum; more than doubling of teachers salaries in real terms since 1990; a reform of teacher education in 17 universities; exposure to best teaching practices worldwide through a program of study-tours, and the improvement of national assessment system (SIMCE) (Cox, 2003). Although the magnitude and scope of the investment has been significant, results have been modest and it is generally accepted that reform has not yet fully reached the schools and their classrooms.

In a recent OECD (2004, p.290) report this was attributed in part to the weak coupling between policymaking and school practice:

> Well-intentioned Ministry reforms are weakly coupled to actual school practice, because there is no supervisory/instructional assistance structure to ensure that the reforms are being implemented as anticipated in the reform programme. Further, teacher education is very important in influencing the nature of school practice, but Ministry reforms are weakly coupled to teacher education, so university preparation of teachers does not necessarily conform to the improved capacity required by Ministry reforms. Finally, school practice is important in influencing student outcomes, so the weak implementation of Ministry reforms resulting in little improvement in school practice results in little improvement of student outcomes

However, as recently pointed out at a meeting in Santiago of the OECD Global Forum by the Head of the Curriculum and Evaluation Unit at the Ministry of Education

> Comparatively good assessment systems can be set up quickly, far more quickly, cheaply and with higher visibility than the effective support systems for teachers that are required for them to reach the new performance levels that policies demand. I would argue that there is a built-in bias in ministries of education in favor of accountability and pressure, which -intended or not– result in an imbalance against teachers' capacity building policies, which are more expensive and difficult to set up and less visible for the public in the short run" (Cox, 2005).

In this article we will describe how and why the ECBI Program, which was initially conceived by the scientific community as a contribution to the desired renewal of the teaching and learning of science, has become a model for strengthening the weak bonds between policy making, teacher capacity building, school practice and student outcomes.

Development of the ECBI program in Chile

Systematic work to develop the program began in 2002 under the leadership of Jorge Allende, a distinguished Chilean biochemist. International support from the National Sciences Resources Center (NSRC), the French Academy of Sciences and the Fundación México-Estados Unidos para la Ciencia (FUMEC), was crucial in the process that led to the engagement of the Chilean Ministry of Education as a partner of the Chilean Academy of Sciences in this mission.

In 2003, a pilot project, involving 1000 children, was implemented in 6 elementary schools of the district of Cerro Navia in Santiago (grades 6 and 7). The following year, the project was extended to 24 schools and two neighboring districts (Lo Prado and Pudahuel), reaching approximately 5000 children (grades 1–4 and 6–8). These municipalities are located approximately 10 Km northwest from the city center. The children that attend these schools belong to families having monthly incomes between 175 – 220 US dollars and exhibit a high index of social vulnerability that affects their quality of life and learning opportunities. Parents have, on average, 8.5 years of schooling.

During the first two years, the program was co-sponsored by the Ministry of Education and the Fundación Andes, a private foundation that promotes new initiatives in education in Chile. In 2005, results of the pilot project induced the Ministry of Education to allocate, a specifically targeted budget to implement inquir-based science education in the schools. The ECBI Program thus became a national program, which is coordinated by the Ministry of Education, alongside a pre-existing initiative to improve literacy and numeracy skills. Forty new schools, from regions outside of Santiago, were incorporated and the coverage increased to approximately 20.000 children. The growth of the program, and its new direct dependence from the ministry, required

a change in the organization. The present structure of the program rests on agreements that are reached between the Ministry of Education and Chilean universities. The participant university is required to adhere to the systemic model of reform (see below), use materials and professional development strategies that have been certified by the program and develop a cooperation scheme that includes the schools, the districts and the scientific community. In addition, the university must ensure the interactive collaboration in the project of academics from both their Education and Science departments.

Three agreements were reached in 2005 with the universities of Chile, of Concepción and of Playa Ancha to set up the ECBI Program in three different geographical regions of the country. The leaders of the regional programs meet regularly at the Ministry of Education to coordinate actions, evaluate progress and plan ahead. The Chilean Academy of Sciences continues to be an active participant of the international component of the project. In 2006, the ECBI Program is being extended to three more geographical regions, with a total coverage of 30.000 children . It is also involving three new universities: the University of La Serena, La Frontera and Talca. This means that half of the regions in the country will have schools engaged in the program under the leadership and alliance of six universities.

A systemic approach: The five components of the ECBI program

The implementation strategy of the program is systemic and follows the model developed by the National Sciences Resources Center (National Academy of Sciences - Smithsonian Institution). It includes five different components: curriculum, professional development, material resources, community support and evaluation.

The driving force of the program is the construction of nearness, complementation and partnership between the scientific community and the school system. This new form of relation is expected to influence the interactions within the school itself. It is predicted that the strategies that are required to transform the traditional teaching and learning approach -based on conceptual content and information- into one that also emphasizes the development of competences and abilities, will impact the whole system promoting leadership, autonomy and the cooperative work of its members.

1. Curriculum: The inquiry-based methodology

The inquiry-based teaching approach is supported on knowledge about the learning process that has emerged from research (Bransford, Brown, & Cocking, 2000). As clearly expressed in the guide for teaching and learning through inquiry edited by the National Academies:

> From birth children employ trial-and-error techniques to learn about the world around them. As children and as adults, when faced with an unknown situation, we try to determine what is happening and predict what will happen next. We reflect on the world around us by observing, gathering assembling, and synthesizing information. We develop and use tools to measure and observe as well as to analyze information and create models. We check and re-check what we think will happen and compare results to what we already know. We change our ideas based on what we learn (Olson, & Loucks-Horsley, 2000, p. 5).

This is a similar process to the one used by scientists to study the natural and material world in search for new knowledge. In inquiry-based science education, children become engaged in many of the activities and thinking processes that scientists use to produce new knowledge. These involve asking questions, gathering information, proposing explanations, subjecting them to test, obtaining results, analyzing the results obtained, proposing explanations, communicating their findings to others and considering the new evidence that emerges from this interaction. This process is guided by their own curiosity and passion to understand.

Evidence shows that this methodology does not only facilitate the learning of scientific contents, but it also offers students the possibility to develop scientific thinking. The learning of major concepts is very naturally built on to previous knowledge and students are able to formulate new knowledge by modifying and redefining their concepts and adding to them. The methodology favors the recognition of inconsistencies between previous beliefs and new observations, and in this way facilitates learning. Since in this type of methodology the children are given the chance to articulate their own ideas, compare them and contrast them with the ideas of others, they are able to improve their capacity to recognize when they have understood and when they need more information, that is, they develop the ability to monitor their own learning (Harlen, 2000).

Learning is guided by the standards-based programs set and developed using research strategies by the NSRC and registered as Science and Technology for Children (STC). There are eight units for grades 1-8: Comparing and Measuring, Plant Growth and Development, Changes, Motion and Design, Properties of Matter I, Food Chemistry and Properties of Matter II. Each unit is developed during one semester. Science lessons are structured following the learning cycle: focalize, explore, experiment, think and apply. In a typical lesson, the children think over a problem, raise questions and share their views, make observations, record their results and analyze the relation between their predictions and the results observed. At all times they are encouraged to communicate their thoughts and experiences as well as to listen to and learn from others. Special emphasis is placed on the use of the science notebook. Since 2005 a process to develop eight new units that are aligned with the Chilean curriculum has been taking place.

In the following paragraphs we present evidence mostly obtained from the children notebooks. In these notebooks children are encouraged to write not only their experiences and observations, but also their thoughts. After each lesson they are invited to answer in writing the question "What did I learn?" On other occasions, they have been asked to express their thoughts about the program through ad-hoc questionnaires. The quotes are from different students.

> Today I learned to compare the density of different substances by answering some questions and whenever I answered, I learned. We also compared different objects such as wax and aluminum blocks, and blocks made of transparent plastic and white plastic. If I go on learning I will become the best of all scientists. I also learned that someone intelligent could go really wrong. *Grade 6 student, Cerro Navia, 2003.*

In these few lines, the student described not only what learned, but also how he learned it and even the consequences that learning might have on his life. In the last sentence he shows understanding about the nature of this type of learning experience.

> I learned a lot. I never thought that this school would give us the opportunity to learn and also give us free materials. The teachers know a lot and they teach us what they know. They also learn with us because we make comments, reach conclusions and give opinions. I learned about volume, density, mass etc. *Grade 6 student, Cerro Navia, 2003*

This student is fully aware of the process that is underway, he recognizes the difference with the former situation, but is nevertheless respectful and grateful to the teacher, who has continued to teach him. His comment shows that he understands that new opportunities arise because a new methodology is being employed and that the teacher is receiving support.

> My life changed, as did that of my classmates and my teachers. I learned that things are not always as I would like them to be and I learned to share with my classmates and with the class. *Grade 6 student, Cerro Navia, 2003*

The student recognizes a major effect of the new methodology implemented by the program, not only on their own life as learners, but also on their teacher. He acknowledges and values the new experience and the effect it has on his relations to others.

> We believe that in this short time with the ECBI project we have learned a lot about science and we agree with the timetable. However we think that we should have more time to do experiments. We would like to use a different uniform with white coats like those of scientists and we would agree to raise money to pay for the cost. *Grade 7 student, Lo Prado, 2004*

The student acknowledges that he has learned, and stresses the importance of experimental work. It is evident that they want to have a full experience of science, including its symbols, represented here by the white lab coats.

In July 2005, after the completion of the inquiry-based science, the children in grades 2- 8 were given a questionnaire. Most of the children in grades 1–6 had worked with the methodology for one semester, and those in grades 7–8 for two semesters. The questionnaire which was answered by 360 children contained four questions: 1) What did you like best of the science lessons?, 2) What did you not like?, 3) What was the most important learning you had? and 4) Do you believe that all Chilean children should have this kind of science lessons?

For reasons of space, only sample answers to the last two questions will be reproduced here. A different child gave each answer.

Which was your most important learning?

Grade 2 (Weather)

"To classify the clouds and learn the names of the clouds"

" With the experiments one cannot play"

Grade 3 (Plant Growth and Development)

"How the bee pollinates and that from a flower a fruit is born"

"The plants should be treated with love"

Grade 4 (Changes)

"All type of solid, liquid and gas can be mixed, but sometimes they cannot be separated"

"To have our own ideas and work in a group"

Grade 5 (Motion and Design)

"What are distance, trajectory, force, friction and the standard vehicle"

"I learned to share"

Grade 6 (Properties of Matter I)

"To determine density, the volume and mass"

"To work and respect my classmates in the group"

Grade 7 (Food Chemistry)

"That all foods are useful for people to grow"

"How to eat with balance, to think and to reflect"

Grade 8 (Properties of Matter II)

"That science is important for humanity"

"To tolerate, to organize ourselves without a teacher and to communicate what we have learned"

Do you believe that all Chilean children should have this kind of science lessons?

"Yes, because one must know what it is to investigate in science, if you did not know how to investigate in science, you would not know science" *Grade 2.*

"Yes, so that when the children become parents, they are able to help their children with their science lessons" *Grade 3.*

" Yes, so that when they grow older they can be scientists" *Grade 4.*

"Yes, because if I have science lessons it would not be fair that others didn't" *Grade 5.*

"Yes, because what I learned is beautiful and other children should also know it" *Grade 6.*
"Yes, because in my country there is much poverty and much ignorance" *Grade 7.*

"Yes, because everyone has the right to be important in this country" *Grade 8.*

The following general conclusions can be drawn from the analysis of all questionnaires:

a) The answers given by the children are remarkably similar irrespective of their age,

b) Children at all stages of development appreciate that learning goes beyond scientific concepts and includes processes and attitudes,

c) Children value mostly what they learn and secondly that learning this way is fun, and

d) Similar results are observed in different classes, showing that the program is succeeding in the transfer of the methodology to the teachers. Only two out of 360 children thought the program should not be applied to all Chilean children.

Teachers also show understanding and value for this form of teaching. They recognize that learning has improved and that its scope goes beyond scientific content knowledge. The following comment was written by a grade 7 teacher two months after starting the program in 2003.

> "I see changes in the children: more affection, more enthusiasm, more expectations. They work with more freedom and if they move around the room, it is to share their learning or opinions. In addition, the improvement in language ability is remarkable and a stronger commitment is observed in children with learning and behavioral difficulties." *Grade 7* teacher, *Cerro Navia, 2003*.

One of the most common observations is the surprise that teachers express regarding children who had previously been considered unable to learn and were not actively participating in classrooms activities. The ECBI form of teaching and learning is inclusive as it offers a variety of different opportunities for engagement and involvement. Therefore, it is almost the norm that children who had been excluded from classroom activities, find that the program allows them to re-engage in the learning experience. This has, as expected, a significant impact on self-esteem and general academic improvement.

> "My life changed, I am not the same person. Last night though I worked until very late, I knew that what I am doing has remarkable effects on children learning. My colleagues also stay up until late, but only to mark exams that show that their children have not learned. I am very fortunate". *Grade 8 teacher , Pudahuel, 2005*.

Teachers notice the increase in the effectiveness of their work and develop strong commitment, which is driven by the conviction that children are able to learn more.

> "I used to teach "force and movement" theoretically and I was worried that now I would have to teach it using inquiry methodology. But the results were excellent. The difference is that the children now have internalized the concepts, the children learn and I learn with them", *Grade 5 teacher, Cerro Navia, 2005*

Teachers are aware of the difficulties and challenges of the new methodology, but at the same time, are capable of finding ways to overcome the problems they face. Essentially, they realize that inquiry offers them and the children an opportunity to become lifelong learners. By immersing themselves into inquiry, they fully start to grasp the concept of a learning community.

> "I have enjoyed each and everyone of my lessons with all my classes. I always come out thinking: How can I tackle better this or that subject? How can I optimize time in order to cultivate as best as possible my students' potentialities that are so lacking in stimulation most of the time? As I watch them enjoy these lessons and see their enthusiastic faces, their astonishment, doubts, happiness, anger, etc. I feel more committed ... I cannot avoid recognizing that I feel tired, but at the same time I have the satisfaction of having given the best of myself" *Grade 7 teacher, Lo Prado, 2005*

2. - Professional Development

The application of the inquiry-based methodology implies a series of innovations and transformations, both from the point of view of the content to be taught and also in relation to the ways in which the teacher interacts with students and the rest of the team to assure a successful practice. However, professional development activities in the ECBI program do not have as its only goal to increase teachers' understanding of science or to improve their pedagogical and social skills, they also aim at building capacities to sustain the systemic model for science education and therefore they must also reach the school and district administrators, the scientists and other members of the community. This requires, in addition to designing, organizing and implementing formative activities that can challenge and benefit all members of the team, the

development also of an atmosphere of confidence, trust and mutual interest that will contribute towards the building of a learning community which can be self-sustained and disseminated.

As Michael Fullan (National Staff Development Council, 1999) has said: "School improvement happens when a school develops a professional learning community that focuses on student work and changes teaching. In order to do that, you need certain kinds of skills, capacities and relationships. Those are what professional development can contribute to..."

The model is thus defined as having the following characteristics (Loucks-Horsley et al., 1989)

- It focuses on what the students are to learn
- It models what is expected to occur in the classroom
- It is continuous and it is embedded in the daily work of teachers
- It recognizes the different needs of teachers with different experiences
- It supports systemic change
- It involves all members of the team

The main formal structures that form part of the professional development activities are the following:

1) Workshops for teachers and principals entering the program.

Teachers attend the workshops together with their principal and the pedagogic head[1]. District administrators are also invited to join the school teams. The participation of the school and district senior administrators at this stage has been shown to be is essential for the successful implementation of the program. These workshops have a duration of 40 hrs and through them: a) principals and teachers develop a shared vision, b) teachers learn about inquiry through inquiry,

[1] Most Chilean schools have an administrative head or principal and a pedagogic leader who is concerned with teaching and learning activities and professional development in the school.

c) teachers learn science content by becoming involved in the same activities as the children and d) teachers and principals prepare a plan for the management of the program. During the workshop, teachers have contact with a significant number of experts.

2) Workshops for teachers that have been in the program one or two years.

In these workshops principals and teachers evaluate results, teachers improve their understanding of science content, teachers and principals from different schools share best practices and learn science content. In this case there is a closer interaction with a more significant number of scientists. Monitors (see below) and scientists plan and teach together, mimicking the relationship that is established between teacher and monitor in the school classroom.

3) *In-the-classroom professional development for all teachers with assistance from a monitor*.

Monitors provide the most important part of this continuous professional development,. They are specially trained teachers and science graduates, who have as their main function to support the teachers in the development of effective learning experiences. This implies working with the teachers before and after each science lesson, as well as assisting them in their work with the children. For the first three years of implementation, teachers are accompanied in their classroom by a monitor for 3 hours per week and an additional 90 minutes during their planning. The work of the monitor is highly valued by the teachers (see below).

At present, the ECBI program has 44 monitors that work half time. The group of monitors is diverse in age, professional background and experience. It includes elementary and secondary schoolteachers, with or without post-graduate studies; biologists, one sociologist and one engineer. Some of the teachers have worked for 30 years and others are just finishing their initial

training, some have worked in private elite schools and others in deprived schools. We believe that this diversity contributes to a richer learning environment. However, these monitors share certain essential common features such as a great interest in increasing their knowledge and skills regarding inquiry-based methodology, ability to listen, support, teach and empathize. Monitors contribute to the teacher's professional development essentially by modeling. This approach ensures an efficient transfer of the methodology and it stimulates the development of a learning community. There is a continuous program for the training of the monitors.

> "In each school, before the lesson begins we have 90 minutes to plan with the teacher. During this time we also evaluate the result of the previous lesson, we review the content, the objectives and we prepare the materials that are necessary for experimentation (...) In my view, what is most important at this moment is to visualize the questions and doubts that children may have, and in this way prepare ourselves to address them. If we do it well, we will be able to help the children elaborate new questions, so that they can move forward in building their own knowledge.
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> (...) In the classroom, the teacher, the children and the monitor are one team and each one has a task to perform. Mine is to support and collaborate with the teacher as she works with the children and to make sure that the different stages and dimensions of the inquiry method are present and carried out as planned" (A *Monitor who is a sociologist, 200).*

4) Professional development program for monitors.

There is a continuous professional development program for monitors that includes an initial workshop of 24 hours, and an in-service program through weekly 3 hour meetings dealing with organizational issues, planning and evaluation as well as training for each teaching unit. The monitors work in close association with each other and also in direct contact with the pedagogical leadership of the project.

5) *Strategic planning workshops for the leadership teams responsible for starting new programs*.

One of the objectives of the program is progressively to expand its coverage, reaching more children, teachers and schools in different regions in Chile and also other countries. This requires a thoughtful plan to prepare the teams to access decision-makers, detect and attract potential leaders and provide assistance and training at the start of the new programs. The program collaborates in the development of these capacities through strategic planning workshops following the model developed by the NSRC. Two strategic planning workshops have been carried out (2004, 2005) with the participation of 16 teams of academics (scientists, educators), administrators (municipalities, schools), teachers and educational experts (ministries, foundations). Half of these teams have been from countries different from Chile - Argentina, Bolivia, Brazil, Colombia, Panama, Peru and Venezuela. The overall goals are to: a) develop a shared vision for inquiry-centered science learning and teaching, b) explore ways to translate this vision into a reality, c) visualize the different dimensions involved in the implementation of an inquiry-based science learning and teaching program, d) provide networking experiences to the participants, d) envision potential actions directed to international cooperation. Participants leave the workshop with a first draft of a 3-5 year strategic plan. The ECBI Chilean team participated in July 2002 in this type of activity organized in Washington by the NSRC and recognizes that the experience was crucial for the successful development of the program.

3. Materials.

To ensure that the inquiry-based science curriculum reaches the classroom teachers need to be provided with all the materials they need. It is important to change the concept that it is the teacher' responsibility to develop materials and collect the needed resources for teaching, even in the absence of economic restrictions, for this has proved to be unrealistic and inefficient. The materials used in the ECBI program have been acquired and assembled in Chile from prototypes

donated by the National Sciences Resources Center (NSRC). In this way, a cost-effective system to provide appropriate materials to all classrooms has been developed. Small materials' centers have been implemented in each school and there is underway and will be piloted in 2006 a project to organize a first material resource center to serve three districts. Experience has shown that science will be taught more effectively if science materials are managed outside the school and made available to teachers when they need them. Thus, the most effective way to deal with this problem is to establish a science material support center (National Sciences Resources Center, 1997).

4. Administrative support and involvement of the community.

The program has made an effort to involve several members of the social community that are relevant to the program. Aside from the scientists directly involved in developing the program, other scientists from different universities, disciplines and countries have participated and met with the children and with the teachers. Teachers of other subjects and school authorities have participated in workshops dealing with the methodology employed and contacts with the business community were initiated in 2005.

Parents have also played and important role in assisting teachers in the classrooms and in the handling of the materials. According to reports from school principals and teachers, the program has increased parental commitment to school activities. Parents and other members of the community have been specially exposed to the progress of their children through the organization of "Public Lectures" in which the children report on what they have learned. Public lectures are held after the completion of each study unit and they are the main instrument to make the program known to the community (families, political and academic worlds) and are also a crucial

instance for assessment. It is often at the public lecture when the teachers come to see and appreciate the changes that the children have gone through.

5. Evaluation

Evaluation considers the school as a system and at present includes the following actions or instruments: a) assessing children's learning on science content and scientific thinking by means of a written test applied before and after a module, b) assessment of children notebooks, c) direct follow-up by the monitors on teacher performance, children learning, classroom and school environment; d) assessment of the impact of the program in the school through written questionnaires and interviews directed to principals, teachers and children. Data is also available from national and international assessments (SIMCE and TIMSS). Efforts are being made to implement a long-term evaluation process that is congruent with the objectives of the ECBI program. An external evaluation of the program will be carried out in 2006, which will have an international component linked to an initiative of the Inter-Academy Panel to develop and international assessment protocol for inquiry based science education (see below).

6. Transfer and international cooperation

As was stated above, one of the objectives of the program is progressively to expand its coverage, reaching more children, teachers and schools from different regions in Chile and also other countries. A plan to transfer the experience through the organization of strategic planning workshops is underway and is proving very successful. Through these activities the Chilean ECBI Program has stimulated the establishment of similar programs in Venezuela, Peru, Bolivia and Panama. It has also strengthened its bonds with similar programs, which are underway in Colombia, Brazil and México. As happens within the classrooms these interactions are guided by

the principle of cooperation with respect and attention to the development of new ideas. This approach has also been used to expand the program in the public system. In addition, the program is having an influence on science education in nine private schools that have adopted the methodology (Fundación Belen (7), Saint George´s College, Experimental School Liceo Manuel de Salas) and a cooperation agreement has been established with the Alliance Francaise school (La main à la pâte) to share experiences and best practices.

The Chilean ECBI Program has greatly benefited from international cooperation. From the start, it received the support of people and institutions carrying similar projects in Latin America (México, Brazil, Colombia) and other parts of the world. This help has come in many different forms that include training of the leadership team, the right to use high quality materials; the sharing of translated material, collaboration in strategic planning workshops and the participation and organization of international conferences. Since 2004 the Chilean Academy of Sciences is coordinating the Science Education Program of the Inter Academy Panel (IAP) and the Interamerican Network of Academies of Sciences. At present the IAP is coordinating the implementation of an international protocol for the assessment of inquiry based science education programs.

Conclusions

After the first three years of implementation, we value especially the systemic character of the program. It is noteworthy that, at each level of the school community involved, important qualitative changes have been observed. Results show that changes have occurred in each of the five components.

Among the most important achievements the following can be emphasized: positive changes in classroom atmosphere with better collaborative relations and stronger team work; progress in the learning autonomy on the part of students; increase in motivation to learn more and better participation of children considered to have learning difficulties. Teachers report that class attendance has increased and is higher those days when science lessons are scheduled compared to the other days of the week. They also report that the children that attend these lessons exhibit greater responsability, enthusiasm for learning and commitment with respect to children that attend traditional lessons.

The ECBI program stimulates children's ability to express their thoughts orally or in writing. Consistently, there is evidence that those children, who are engaged in the program, write more in their notebooks and have increased their vocabulary. The importance of communicating ideas and experience, subjecting them to test and to the consideration of others and to getting information from different sources is constantly cultivated and encouraged. This occurs through group discussions and oral presentations and reaches its maximal expression in the public lessons delivered at the end of each unit. This is when students, with the assistance of their teachers and monitors get organized to share their learning with parents, visiting scientists and other members of the community.

Among the teachers, we notice a progressive adaptation to the new methodology and an increase in knowledge of science content and teaching methods which contributes to a better self-evaluation, generates autonomy and a better disposition to innovate in their pedagogic practice.

In the schools, it is evident that the collaboration between authorities and teaching staff is improving. The role of the monitors in the project has been essential for this to happen.

Throughout the shaping of the project the monitors have given their support during the realization of the activities in the classrooms, and have greatly contributed to the follow-up.

The results of the project are best seen and conveyed through the opinions of the principals and the academic directors of the school (2005):

About the children:

- "The children are eager to give their opinions and are not afraid to make mistakes, they question more and they express a need to verify". *Violeta Parra Elementary School.*
- "A remarkable increase in class attendance and improvement in behavior and personal presentation is observed". *El Salitre Elementary School.*
- "There is a positive attitude towards the science lessons, enthusiasm, participation and team work". *El Salitre Elementary School.*
- "The children are revolutionized with the new materials that they work with". *Complejo Educacional Pedro Prado School.*
- "Science has attracted the interest of the students that had been previously considered as having learning difficulties". *Complejo Educacional Pedro Prado School.*
- "Students have improved their oral expression, they act with greater autonomy, they have learned to work cooperatively, their argumentation is clearer, more precise and reflexive, and what is more relevant: these characteristics have been observed by other teachers that work in other subject matters. *República de Italia Elementary School*

About the teachers:

- "Teachers have changed their views about science education and they enjoy verifying that the children are able to express what they have learned."
- "There is discussion about the development of the project in the classroom, what works and what doesn´t. Teachers are constantly evaluating their practice. Since all teachers are involved there is a greater commitment to help each other". *Complejo Educacional Pedro Prado School.*
- "The methodology changes the relation between students and teachers, generating solidarity which is evident in their effort to reach consensus" Millahue Elementary School.

About the monitors:

- "The role of the monitors has been crucial for the good implementation of the program, for thousands of reasons: The most important one being the constant support offered to the teachers. They are an objective referent that nourishes the project from within. They

have helped to ground the methodology in the classroom practice". *República de Italia Elementary School.*

- The monitors are highly committed and they are clear as to the role that they must play in the school, both in the professional development of the teachers and in reassuring the learning of the children. They are creative and versatile. They are aware that mutual support that must be developed with the teachers. *Manuel Guerrero Ceballos Elementary School.*

About the parents and the community:

- "Parents are more aware of what happens in the classroom and more committed; some are cooperating with the activities. They are also more involved in the school" *Complejo Educacional Pedro Prado School.*
- "Parents and teachers are proud to participate, both because of the contacts established with academics, scientists and professionals, and also because of the good achievement results, the development in our students of self-esteem and self-appreciation in the academic domain, as well as the good performance of the teachers." *Poeta Vicente Huidobro Elementary School.*

About the infrastructure and the materials:

- The experimental material is excellent, without it the children would no be able to live through the scientific processes that ultimately explain their own existence. *Monseñor Carlos Oviedo Elementary School.*
- "There is a better and more efficient use of some spaces in the school with objectives that are centered on the project (science room, gardens)" *Manuel Guerrero Ceballos Elementary School.*

But it is the children themselves that always more eloquently express the importance of the program:

"Before everything was theoretical and it didn´t convince.

Now we see it with our own eyes"

6th Grade student, Cerro Navia. Santiago de Chile

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