Inquiry Based Science Education

Promoting changes in science teaching in the Americas

Inter-**American** Network of Academies of Sciences
Global Network of Science Academies

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IANAS INTERAMERICAN NETWORK OF ACADEMIES OF SCIENCES

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IANAS The Inter-American Network of Academies of Sciences

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Foreword

As is quite well accepted today and was recently noted in the 2017 statement from the G7 Academies of Science, many aspects of present-day society have benefitted from science and technology. As there is no doubt that this will continue in the future, it is essential that we have the appropriate educational systems in place throughout the globe to teach all citizens the basic elements of science and on how science and technology have an impact on many aspects of everyday life. It is also important for them to understand how science, technology and innovation has a key impact in the present and future developments of our societies as well as being essential to train our future scientists. Furthermore, it is important that these programmes are structured to include women and minorities in both developed and developing countries. It is also important that students who do not follow a career path in the various fields of science and engineering receive a solid background in the sciences for two rather different reasons. The first is that science courses will help develop their critical thinking skills that will serve them regardless of their career path. The second is that with a science background they will be equipped to participate as engaged citizens in issues relating to science.

Providing children, starting early in primary school, with effective Inquiry-Based Science Education requires well developed curricula, qualified teachers and the support of local and national boards of education. IANAS recognised this from its early days explaining why the Science in Schools programme was one of the first inter-academy collaborations for the network. However, the challenges faced when achieving these goals vary significantly between countries. This publication is a review of the focal group's activities over the past decade, considering both the successes and failures, with the view of learning from our collective experiences to improve all aspects of future Inquiry-Based Science Education (IBSE) as well as the STEM (Science, Technology, Engineering and Mathematics) teaching programmes throughout the Americas. We also hope that this retrospective will help others wishing to develop effective IBSE and STEM education elsewhere in the world.

Juan Asenjo
IANAS Co-Chair
Chilean Academy of Sciences

Jeremy McNeil
IANAS Co-Chair
The Royal Society of Canada: The Academies
of Arts, Humanities and Sciences of Canada

Introduction

Since the beginning of its activities, IANAS has enthusiastically supported the implementation and development of the Inquiry-Based Science Education (IBSE) program and has repeatedly expressed interest in leaving a written record of the achievements of each country.

Inquiry-Based Science Education is one of the programs with which IANAS began its activities, and has been the focus of attention of all the Executive Committees. It is also regarded as representative of the Network's objectives.

The basic idea of the program was to implement a science teaching model for children to learn the basic principles of science by thinking and working on the basis of the ideas and practices used by researchers in their laboratories. A continent-wide program was organized under the aegis of the Academies of Sciences, from Canada to Argentina, based on the use of certain ideas such as the direct use of inquiry-based methodology in school science classes, collaboration between national programs and the preparation and sharing of educational material. This is an attractive goal which in reality has not been easy to achieve in practice, although it is one we should continue to strive to attain.

This book is a response to IANAS's interest in recording what has been achieved so far in science education, after a long period of reflection.

It reflects the dedication of the Focal Points and teachers to bringing the idea to schools, despite the difficulties encountered and of the Academies to contributing to building a better future for their countries through education. It also describes the enthusiasm this teaching approach elicits in children, which could easily be taken for granted, and in the teachers who have been involved, and highlights at least three aspects common to all the countries involved: the interest of the Academies, especially the Focal Points, in changing the way science is taught at schools; the similarity of the problems to be addressed; and the predictable diversity of approaches and interests of education ministries.

We think this is an important testimonial that reveals the possibilities and obstacles to be overcome to make science education in our region relevant. Every reader will establish his own criteria for this.

In order to serve as a guide for the programs that have yet to be implemented and those that are about to do so, this book is divided into three parts: the first one summarizes the program's philosophy and justifies its implementation; the second one brings together the contributions of the various Focal Points, and the third one highlights the lessons learned over more than ten years of work.

The first part, which describes the structure of the program, indicates what it should consist of when conditions are in place to implement as it was designed, which is not necessarily possible in all countries. It also draws attention to the essential features for implementing it properly, which is valid regardless of the conditions or realities of each country. There is obviously a need for well-prepared teachers to teach science, suitable teaching material and for science to be taught at schools from the earliest stages, as well as appropriate material for giving workshops or children's classes in order to be able to say that a science education program is in place. Although these observations might seem superfluous, they must be borne in mind to achieve the goals set.

In the second part, the Focal Points describe the efforts made in each country to implement this teaching, the approaches used and the main achievements.

Chapters 4 and 5, comprising the third part of the work, present Indágala, a joint effort to support teachers throughout America, together with an overview of what has been achieved to date. It is a sort of conversation based on memories and documentation highlighting certain aspects of the lessons learned. These include the commitment all the Academies must make to the program, in the sense of providing their Focal Points with every possible assistance for them to do their work; the need for academic and administrative support to seek funds to sustain the program; and a group of facilitators with a sound scientific grounding, who will be able to convey their knowledge to their teaching colleagues and the need for cooperation between the Focal Points. These are issues which, among others, will have to be agreed upon to achieve the goal of attaining better scientific education for the school population of our countries.

We invite you to read and comment on the decision by the Academies of Sciences to transform science education as a means of building a better future for our societies.

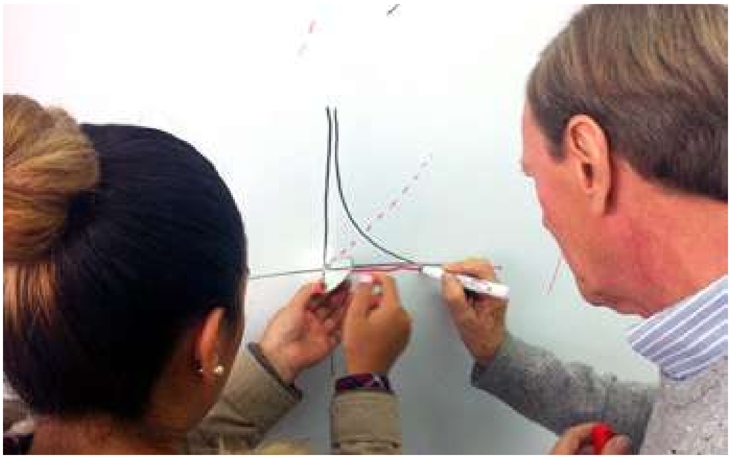
Carlos Bosch
Mexico Focal Point
Mexican Academy of Sciences

Claudio Bifano
Venezuela Focal Point
Academy of Physical, Mathematical
and Natural Sciences of Venezuela

Teachers and students learn at the same time

Teaching science requires teachers to be trained in such as way that they can analyze their own practice, learn about different IBSE experiences and update their knowledge.



"Science classes should be given by teachers who understand the basic principles of science and are able to stimulate children's curiosity and help them develop their experimentation skills so that they can clarify their doubts on their own"

1

What is Inquiry-Based Science Education?[1]

Ever since universities adopted Wilhelm von Humboldt's idea of providing an education focused on teaching, learning and research,[2] scientific inquiry has been used as a teaching and learning tool: The use of inquiry in elementary and middle school education, however, is relatively recent.

Until the early 20th century, the main focus of the study of science was memorization and the organization of certain facts, a practice that is unfortunately still common in science education in Latin America.

The current speed of changes in the world requires a similar change in the meaning of "effective education," particularly as regards science, technology, engineering and mathematics. A good way to do this is by exposing children early on to an educational model in which they themselves are part of the teaching and learning process.

Nowadays, children construct their own ideas about science through the wealth of information they receive from the media that provide ideas on how and why certain natural phenomena occur. But these are usually chronicles or stories that do not always provide a sufficiently clear or accurate interpretation of the issue at hand. In some cases, they are merely intended to elicit astonishment or amazement in children, rather than enabling them to arrive at a correct interpretation of a particular phenomenon.

Information designed to satisfy children's curiosity should be supplemented or clarified by teachers. Communication between teachers and students, however, is often nothing more than a transfer of existing information in books or databases. This bores students, making them feel that science classes are remote from their immediate interests and lives, even though they use technological devices all the time.

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1. **Carlos Bosch** is Focal Point of Mexico, member of the Mexican Academy of Sciences, and professor at the Autonomous Technological Institute of Mexico (ITAM). **Claudio Bifano** is Focal Point of Venezuela, Full Member of the Academy of Physical, Mathematical and Natural Sciences, and professor at the Central University of Venezuela.

2. Humboldt, Wilhelm von (1903-1936). "... A university teacher is not a teacher, nor the student with a student, but one who investigates on his own, guided and directed by the teacher" (GS, XIII, p. 261). "The peculiarity of the top scientific institutions should be the treatment of science as a problem that has not been entirely solved that must be continuously investigated" (GS, X, p. 251). Selected Works, Academy of Sciences of Prussia, 17 vols. (The Works are designated as GS, the Roman numeral indicates the volume, the Arabic numeral the page).

To prevent this, science classes should be given by teachers who understand the basic principles of science and are able to stimulate children's curiosity and help them develop their experimentation skills so that they can clarify their doubts themselves, through experiments using simple, well-structured instructional material, which facilitates teaching and expected learning outcomes.

Improving science education in elementary and middle school education levels is not only intended to train scientists and engineers, but also to improve the scientific culture of society in general and contribute to the development of an organized, critical mind among citizens, which is useful for dealing with everyday problems more creatively and objectively. Rather than natural resources, the development of any country requires citizens with a good grounding in science. And if this basic learning is the result of a motivating teaching system, there will be a sufficient number of young people interested in pursuing careers in science and technology, essential to sustaining and accelerating the development of any country in these areas. Knowledge of or familiarity with the basics of science is crucial in an increasingly technological world, regardless of the activity in which people are engaged. It is essential for everyone to have a basic knowledge of science and technology to explain, for example, their importance in everyday life, their contributions to improving the quality of life and the care that should be taken of the everyday products derived from them.

In response to traditional education, in the 1960s, a research-based teaching method was developed, now known as "Inquiry-Based Science Education (IBSE) in the sciences. This type of education was first introduced by Dewey in 1910,[3] and since then several researchers have used and developed it.

What we call Inquiry-Based science education is a process whereby children and young people answer their own questions and satisfy their curiosity about the world around them through experiments.

Winner of the Nobel Prize in Physics in 1988 Leon Lederman, concerned about the state of neglect and violence in certain public schools in Chicago, used the *Hands On* Program to incorporate this teaching proposal into schools. The program he had developed at the University of Chicago consisted of experimental science teaching in which classes revolve around experiments. The central idea of this methodology is to bring children into contact with natural phenomena and encourage them to explain them. To use this method, science teachers are encouraged to begin their classes in the lab rather than start with a theoretical explanation. That means that science education should be based on looking for the answers to the secrets of nature to enable students to discover basic science concepts on their own rather than through memorization. Based on these criteria, Leon Lederman launched this new approach to science teaching.

The story began in 1986 when a group of teachers of children ages 12 to 15, interested in having their pupils see how scientists work and find out what goes on in a laboratory such as Fermilab, asked to be given a tour so that they could see the highlights of the center. They were allowed to visit on condition they did not interrupt the lab's activities. They were also told they would not be able to visit the most important parts such as the tunnel where the accelerator is located or the space where collisions take place. Fermilab's education office, together with teachers and a number of physicists, developed a working unit for children to study before the visit. That working unit still exists and the essential questions it contains are: How do scientists work? How you can study things you cannot even see? In another unit, students engage in certain scientific practices that lead them to "discover" state-of-the-art concepts in science.

3. Jown Dewey (1859-1952), the father of Progressive Pedagogy.

In an interview, Leon Lederman remarked that, in view of the revolution we are currently experiencing, there is a need to change the way we perceive new technologies and science applications such as telecommunications, computing, the Internet and cloning, in order to participate in their development and be able to rationally apply them to current and future developments. The researcher, who advocated a revolution in science teaching, stated that *the new way of teaching science also involves teaching teachers how to teach science* and placed special emphasis on the need to combat anti-science and to teach young people to distinguish science from astrology or divination. It is also necessary, it might be added, to do away with the misconception that scientific development is only a matter for certain societies and only possible in certain privileged countries.

On a visit to Chicago, Georges Charpak, a fellow physicist, Nobel Prize laureate (1992) and friend of Leon Lederman's, found out about the program and was so excited about it that he enthusiastically promoted it in France until his death in 2010. This gave rise to another focus of influence in science teaching using the IBSE method: La main à la pâte.

In 1996, with the support of the French Academy of Sciences, Charpak launched the La main à la pâte program, which, in 2012, became a scientific cooperation program operating both in France and beyond.

Workshops on Science Education Based on Inquiry in Argentina

Top left photo: "Listening to the Sound" for Elementary School Teachers. Top right photo: "Water Properties" Module for Kindergarten Teachers. Bottom left photo: Universe Module "Moon Phases" for Elementary School Teachers. Bottom right photo: "Chlorophyll Extraction" Module for middle school biology teachers.

"IBSE begins with trainers who have a solid scientific basis and can train teachers"

2

How is an Inquiry-Based Science Education Program constructed?[1]

IBSE teaching begins either by asking questions or making observations or describing a particular scenario. The specific processes students should ideally undergo are as follows:

- Make a conjecture
- Devise their own questions
- Obtain evidence to be able to answer their questions
- Explain the evidence gathered
- Link this explanation to the knowledge obtained during the research.
- Create an argument and a justification for the explanation or else make a new conjecture and begin the cycle again.

It should be noted that in the IBSE, things are not usually linear. Matters are not usually very structured and arriving at a conjecture requires previous work.

2.1 Teacher preparation

It is essential to have teachers proficient in the basics of the various branches of science in order to implement a good science education program, in any form. In the case of IBSE, teacher education is particularly important since children may ask a wide variety of questions both during the experiments and when they are positing hypotheses or drawing conclusions. In these cases, the teacher must be able to answer them or be able to say, "I do not know," something many dare not do for fear of losing face in front of their students.

Often, when talking to teachers, one senses a degree of fear and even panic about giving a science class. They are afraid about not having the necessary knowledge to answer children's sometimes very uncomfortable questions, and they panic about failing to do their job properly: "Science is very complicated, I do not understand it...I'm not scientifically inclined, that's for specialists. They give all kinds of excuses to avoid giving classes.

To help them overcome those fears, it is useful for teachers to know that one of the prerequisites for doing science-and of course teaching it-is humility. Saying, "I do not know" is what makes scientific research make sense. If a researcher assumes he will know the results of his research beforehand, this defeats the point of the exercise. It is precisely not knowing why things happen and, in the case of classes, not having the answer to questions that forces teachers to study to find the answer. This can open up a path that may become even more important than the answer to the question they were asked.

The program should have a number of facilitators trained in research methodology, who have completed a refresher course and reinforced the basic concepts of science, so that they can teach classroom teachers. The group of teacher trainers is the core of the program, since they are the ones who

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can guarantee the training of classroom teachers and the accompaniment they may require when implementing the IBSE program.

2.2 Preparing teaching materials

It is true that in the literature and also on the Internet, there is an abundance of teaching materials, usually very well developed, including videos, games, designs for experiments that can easily be done at school and pages devoted to providing the necessary theoretical foundation. However, this is material which, although it refers to the basic principles of scientific knowledge, is developed according to the needs and realities of education in the author's country, which include the language in which they are written. Accordingly, it cannot always be used in schools in different countries without making the necessary adjustments.

Often the language and the way problems are approached have to be reviewed. In other cases, one has to assess the relevance of the proposals based on the curriculum design and the availability of materials, so the best thing is for each program to develop teaching materials adapted to the users' situation. And since the Inquiry-Based Science Education program is designed to be used throughout the region, the material should be made available to all potential users on websites, acknowledging its authorship without copyright or other unnecessary obstacles.

Each program should therefore have a website available to teachers that includes the teaching material produced in the programs of the various countries and also serves as a means of informing the official education ministries and society on how Inquiry-Based methodology is being used in the teaching of science and the importance of teaching science in this way.

On the other hand, since this is inquiry-based teaching, it is essential for each program to have the necessary material for conducting experiments. And although the material is unsophisticated, each program should have a collection center, or a Resource Center as it has been called that is easily accessible to facilitators when they take the experiment to their schools for science classes or offer training workshops for teachers or new facilitators.

In short, implementing this type of program requires at least three key elements: well-trained teachers in the area of science; attractive, well-designed material for students; and supplies for experiments that are readily available to facilitators.

2.3 Elements required to design an IBSE program

a) Attitude of school authorities

School authorities' attitude and involvement are crucial to the project's success. As noted earlier, the IBSE project is not actually an additional component to the basic science teaching project, since the contents are covered in the curricula. What it does add is the methodology and the preparation of classroom activities. For these reasons, administrators should have detailed knowledge of the program, attend teacher training workshops, collaborate in the organization of the physical space, and encourage and instill in teachers and children the importance of this task, which is often in addition to their regular obligations, to obtain the best possible result. The more administrators and teachers are convinced of its benefits, the more successful the project will be.

b) Minimum requirements for schools

School infrastructure, particularly in classrooms, is important. So that the activities can be carried out properly, a large area should be provided for children and teachers to be able to work comfortably. Tables and chairs are required rather than desks, for organizing working groups, together with access to water, a cupboard for storing the material, electric current and if possible a refrigerator or at least a cooler with ice.

c) A Resource Center

For each module, it is essential to have kits or boxes with all the material for conducting the experiments, however simple, in sufficient quantities for every students. All the materials are readily available and the boxes or kits should be available for use during the class. Obtaining the material and organizing it into kits is a task that requires a considerable amount of time and space.

It is useful to have a Resource Center, in other words, a space to ensure that the experiments provide the expected results with the available material, where teachers can prepare the boxes and store the material to be used. The Center should be administered by a person responsible for the inventory of available material and for taking the boxes to the classrooms.

It is no simple task to organize science classes, and have children “play” at being little scientists; several details must be taken care of to ensure that the attempt is successful and in this section, we have only drawn attention to some of them. This consideration, which may seem secondary, is often crucial to the practical implementation of the program.

Countries that have achieved the best results with the IBCE program have an infrastructure of human and material support. It is hardly surprising then, that France, the United States, Canada, Chile and Mexico should have been able to implement the method most effectively, each in their own way

In the following pages we will describe some of the experiences of these countries, which we have grouped into three blocks.

The importance of designing topic-based unit to work with mathematics

Top left photo: Working with the attributes of certain geometric figures. Top right photo: Experimenting with the properties of certain materials. Bottom left photo: Using balls to work with young children. Bottom right photo: Working with electrical circuits.




"The Academies of Sciences in our hemisphere are working to improve the level and relevance of science education"

3

The start of IBSE in America

ENGLISH-SPEAKING COUNTRIES

3.1 The case of the United States[1]

The case of the United States (USA) began to be explained in Chapter 1. We should just add that after seeing the success of Lederman and his group, the National Academy of Sciences decided to support them by creating the National Science Resources Center (NSRC),[2] comprising the Smithsonian Institute and the National Academies, which develop educational materials as an innovative science learning and teaching strategy to bring inquiry into the classroom. In the late 1980s, the NSRC was responsible for expanding the program by taking charge of both the organization and the contents. The Leon M. Lederman Science Education Center was set up in Chicago to provide support for teachers, by offering workshops and improving their science training.

It is important to note that evaluating IBSE programs is both difficult and costly. In this respect, the recent evaluation of the program called Leadership and Assistance for Science Education Reform (LASER) developed by the Smithsonian Science Education Center (SSEC), could serve as a model for this kind of program worldwide, if it could be economically implemented. A brief description of the evaluation is given below.

The LASER model, developed by the SSEC, is a systemic approach to the transformation of science education, consisting of five elements: a science program based on inquiry and research, differentiated professional development, administrative and community support, support materials and assessment. When these elements occupy a central position in the approach to science, they shape the infrastructure that supports student-centered teaching and learning.

With the leadership of NSRC, and under the influence of its LASER model, many IBSE projects have been launched at the local, regional and state level. Highlights include the STEM project in Washington State, the Alabama Mathematics, Science and Technology Initiative (AMSTI), the GEMS NET in Rhode Island, the Einstein Project in Wisconsin and the Inquiry Science Education Consortium (ISEC) in northern New Mexico. The two largest programs for developing kits for IBCE have been the SSEC's Science and Technology for Children

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2. In 2012, the NSRC was renamed to SSEC (Smithsonian Science Education Center).

(STC) and the Full Option Science System (FOSS) at the Lawrence Hall of Science at the University of California, Berkeley. Both programs are developing new kits to align with the Next Generation Science Standards (NGSS)[3] presented in 2013. The school district of the city of Oakland, California, is serving as a model for the use of FOSS kits to implement NGSS. Another recent development is code.org, which uses inquiry to teach computer science.

So what is LASER i3?

In 2010, the US Department of Education granted SSEC funding to conduct a five-year validation destined for Investment in Innovation (i3) in order to assess the effectiveness of the LASER model in the systematic transformation of science education. "LASER i3" is the longitudinal study resulting from the LASER model proving that inquiry-based science optimizes student performance not only in scientific issues but also in reading and math. LASER plays a key role in strengthening student learning, especially among marginalized populations, including economically disadvantaged children, those who require special education and those who are learning English as a second language.

Evaluators at the Center for Research in Educational Policy (CREP) at The University of Memphis studied nearly 60,000 students at public schools (urban, rural and suburban) at: 1) Houston Independent School District (HISD), 2) eight school districts in northern New Mexico, and 3) seven school districts in North Carolina. CREP used a randomized controlled trial (RCT) of matched pairs with a comparison group and sought evidence to show whether students at schools that had used the LASER model for a period of three years performed better than those who had not been exposed to it during the same period.

The evaluators began the study with a subsample of over 9,000 elementary and middle school cohorts. CREP assessed the cumulative impact of SSEC products and services for three consecutive years in selected elementary (3rd-5th grade) and middle school (6th-8th grades) students. Students included in the intervention were known as the "LASER Group" while those who were not formed the comparison group. CREP reported on students' progress from the initial assessment (Fall 2011) until after the final tests (Spring 2014). In addition to these aggregate data, evaluators collected detailed information on a subset of schools and conducted studies to contextualize the results.

The results were obtained by analyzing standardized state assessments of elementary and middle school students in reading, math and science.

In order to compare students in the three regions, schools participating in the study also used features of the Partnership for the Assessment of Standards-Based Science (PASS), comprising multiple-choice questions, open questions and practical performance tasks.

The LASER i3 study shows that inquiry-based science improves the performance of students at all levels of elementary and middle school, not only in science, but also in reading and math. As a result of this validation, the SSEC will continue its work to transform science education and support LASER i3 regions in their efforts to maintain and continue the great work that has already been done.

3.2 The case of Canada[4]

Since education in Canada is under the jurisdiction of the provinces, it varies slightly from one to the next. There are no national plans and programs; instead, each province develops and implements the curriculum of its choice. Nevertheless, science and math syllabi do not differ much between provinces. However, it is important to note that in the last report on PISA evaluations in mathematics, the performance of Canadian students highlights major differences between provinces, although they all achieve better results than the highest results

3. The basis for NGSS was the publication of *A Framework for K-12 Science Education* developed by the National Research Council (NRC) of the National Academy of Sciences (NAS).

4. **Patricia Rowell,** Focal Point Canada, Professor Emeritus of the University of Alberta.

obtained in Latin American countries and, with the exception of Prince Edward Island (479), they all perform better than the US (481). The next province is Newfoundland and Labrador (490) and results continue to rise until they reach the province with the highest score, Quebec (536). These disparities show differences due to the language used in the school system. It is important to note that Quebec has had an IBSE program for approximately ten years.

However, here we will focus on the province of Alberta (517), or rather the activities that have been carried out there. For over twenty years, Alberta's elementary schools have adopted the IBSE approach. All Alberta teachers spend at least four years at university, leading to a Bachelor of Education (B. Ed.) degree. During this period, basic education teachers take at least one science course and another on how to teach science.

Alberta therefore has an extremely solid program, with a long tradition that transcends the Royal Academy of Canada and in which teachers enjoy the support of local universities.

3.3 Other English-speaking countries in America[5]

Inaugurated in 1988, The Caribbean Academy of Sciences (CAS), now in its 27th year, can be proud of the success achieved since its inception. The Biennial General Meeting on Science and Technology continues to be one of the highlights of the CAS. Although we are pleased with our achievements, much remains to be done. We know that development is ultimately about and for people. Part of our duty as scientists and technologists is to improve the quality of life of people in the Caribbean region. One of our goals is to create scientific awareness in the region and to enhance people's understanding and perception of the importance and potential of science and technology in human progress. To this end, the CAS has organized training workshops for elementary and middle school teachers on Inquiry-Based Science Education (IBSE).

At a Science Education meeting, held in October 2007 in Jamaica, CAS concluded that science education would be one of the main activities of the Academy in collaboration with the Ministries of Education, Teacher Training Colleges and environmental groups in general, together with non-profits in related fields. Within this framework, CAS has been actively participating in the Science Education Programs of the Inter-American Network of Academies of Sciences (IANAS).

From a historical point of view, one can speak of two pedagogical approaches in science education. The first of these, traditionally used at schools, is the "deductive approach". In this approach, "the teacher presents concepts, their logical-deductive implications, and provides examples of their application... In order to use this approach, children must be able to handle abstract concepts, which makes it difficult to start teaching science before secondary school. Conversely, the second one has long been known as the "inductive approach". This approach provides more scope for children's observation, experimentation and creation on the basis of their own knowledge under the teacher's guidance. The terminology has evolved and over the years and as a result of the refinement of the concepts, this inductive approach is now known as Inquiry-Based Science Education (IBSE) and is used particularly in natural sciences and technology". One of the main findings of the report is that, "A change of course in the teaching of deductive science mainly to inquiry-based methods provides the means of fostering interest in science".

In response to the current crisis in the region, CAS, in collaboration with IANAS, organized a Workshop on Science Education for Elementary Teachers on October 9 and 10, 2008 on Inquiry-Based Science Education Methods (IBSE) at the Grenada Grand Beach Resort, Grand Anse, Granada. This first workshop was held in collaboration with the government of Granada, IANAS, CBD and OAS. Follow-up workshops were conducted in Guyana (2009), Antigua (2010) and Guyana (2012). The Chilean experience in Inquiry-Based Science Education was made public as part of the teacher

5. **Winston A. Mellowes,** Focal Point Caribbean Academy of Sciences (CAS), and Professor Emeritus **Ms. Petal Punalall-Jetoo**, Science Coordinator NERC Guyana.

training workshops in 2008 and 2009. The authors also contributed to the Conference on Learning and Teaching Science and Mathematics with the following topic: "Science and Math Teaching in the Caribbean and Latin America" at The Mico University College in Jamaica, as part of the celebrations of its 175th anniversary in March 2012. UNESCO's micro-science experiments and the IBSE approach formed part of the interactive session on science education.

Successes

Mrs. Punalall Jetoo played a key role in promoting the IBSE program in Guyana. The following excerpt on Guyana was written by her.

Guyana began a series of training workshops for teachers as a follow-up of the Workshop on Inquiry-Based Science Education Methods (IBSE) for Elementary School Teachers held on October 9 and 10, 2008 at the Grenada Grand Beach Resort, Grand Anse, Granada. The IBSE approach was subsequently shared with middle school teachers as an effective means of developing science teaching skills. The number of training workshops for teachers rose from twelve in 2009 to 41 in 2014. These workshops were organized and made possible by the Science Unit, the National Development Center for Educational Resources (NCERD) and the Ministry of Education. Workshops were also given at schools. In 2012, the Science Unit secured funding from UNESCO to launch a pilot program in Inquiry-Based Science Education for grades 5 and 6 at six elementary schools. Four other schools were incorporated into the pilot program thanks to financial support from Exxon Mobil in collaboration with Youth Challenge Guyana.

Through the Caribbean Academy of Sciences, Guyana described the implementation of the IBSE pilot program at various conferences and workshops such as The Mico University College Conference in 2012 and the Third Annual Workshop of the Caribbean Science Foundation (LCR) 2013. The IBSE program was based on the issue of climate change. Lessons were prepared in science and social studies for grades 1 to 6. Pilot science modules are currently being implemented at 16 elementary schools. The pictures below show the organization of IBSE teacher training workshops taught by the National Center for the Development of Educational Resources.

Inquiry-Based Science Education was also presented at the Third Annual Workshop of The Caribbean Science Foundation (CSF) held in Guyana in 2013.

Grenada

As a follow up to the first Science Education Workshop on Inquiry-Based Science Education Methods at the Caribbean Academy of Sciences for Elementary Teachers, held on October 9 and 10, 2008 at the Grenada Grand Beach Resort, Grand Anse, Granada, a team of teachers (Davis John, Jervis Viechweg and Michelle Noland) developed a brochure that included lessons for Inquiry-Based Science Education. Science teachers and leaders from six elementary schools were trained and asked to share their knowledge with other teachers at their schools. Mr. Davis John gave additional workshops with the staff of St. Patrick's Anglican School, where he teaches.

LATIN AMERICAN COUNTRIES

3.4 The case of Colombia[6]

IANAS was established in May 2004 with two institutional programs: Education and Water. The Colombian Academy of Exact, Physical and Natural Sciences signed IANAS's Charter and began participating in the two programs. By 2004, there were IBSE Programs in seven countries in America: Canada, USA, Mexico, Colombia, Brazil, Chile and Argentina. Colombia's Young Scientists' Program, one of the first in Latin America, dates from 2000. That year, an agreement was signed between the University of the Andes, Maloka and the Louis Pasteur French Lycée to promote an IBSE program in Colombia, based on the initial experience between 1998 and 2000 of that French school in Bogotá and consistent with the La main à la pâte program in France.

The Academy had had some contact with the Young Scientists' Program and got in touch with it again. It was discussed whether or not the Academy should try to create its own program. The Academy finally decided to support the existing program, which had already accumulated significant experience in the public education system and adhered fairly closely to the guidelines of the Science Education Program promoted by the Academies, since it had been inspired by the US and French programs, both promoted by the Academies of their respective countries.

In October, a five-person Colombian team with representatives from the Ministry of Education, Young Scientists and the Academy, was invited to Chile by IANAS to participate in a strategic planning workshop on Inquiry-Based Science Education (IBSE) projects.

Eventually, on May 25, 2005, the agreement was expanded to create the Young Scientists' Alliance comprising the University of the Andes, the Moloka Corporation, the Louis Pasteur French Lycée, the Education Alliance, the French Embassy and the Colombian Academy of Exact, Physical and Natural Sciences. Under this agreement, the Colombian Academy of Sciences undertook to:

1. Seek coordination with the science academies of other countries, especially with IANAS and InterAcademy Panel (IAP)[7], with the goal of strengthening the exchange of programs and materials.
2. Seek coordination between the Young Scientists and other inquiry-based programs, supported by the science academies of their respective countries.
3. Provide scientific support to the project by facilitating links between scientists who offer support for the project.

This strategic partnership operated successfully until 2010 and the Academy also successfully performed the activities it had pledged to undertake within the agreement signed, but in 2011 it was dissolved. However, the Focal Point remains in contact and at the IANAS Education Program Meetings, an updated report is presented on the status of the Young Scientists' Program.

Since the Young Scientists' Program has special features, like all the national programs, and already existed when IANAS was established in 2004, Margarita Gómez, the current coordinator of the program, prepared the following summary:

The Young Scientists' Program was created in response to the need to encourage and transform science and technology education in elementary schools in Colombia (Duque, Figueroa, & Carulla, 2002). This initiative by the University of the Andes Engineering Faculty was based on internationally developed proposals. In particular, the Colombian

6. **José A. Lozano,** Focal Point Colombia, Honorary Member of the Academy of Sciences; **Margarita Gómez,** Coordinator of the Young Scientists' Program at the University of the Andes, Bogotá; and **Ismael Mauricio Duque,** Academic Coordinator of Young Scientists' Program at the University of the Andes, Bogotá.

7. In 2016, IAP changed its name to the InterAcademy Partnership.

program was inspired by the work carried out in France through the "La main à la pâte" program led by Nobel Laureate physicist Georges Charpak.

The French proposal, adopted and subsequently adapted by the University of the Andes, is based on the underlying principles of how science and technology are learned and taught. In a Young Scientists' class, students observe a real problem and do research that allows them to discover the knowledge associated with the problem. To achieve this, they develop hypotheses and put forward arguments in their own words, discuss their own ideas and construct scientific knowledge (Belay, 2006).

This approach to science and technology teaching requires students to devote sufficient time to problems and to solve them using logical sequences in which they gradually progress towards the construction of concepts (Worth, Saltier, & Duke, 2009). This means that the teacher must have the materials and teaching resources to involve students in small research projects in which they will act as "little scientists" by making observations and conducting experiments to construct knowledge that is new to them (National Research Council, 2000).

During the 14 years since its inception, the Little Scientists' Program at the University of the Andes has constructed and validated a framework that explains the objectives, means and resources required to implement a strategy that transforms the quality of education in science, technology, engineering and mathematics (STEM) at elementary school.

The program has provided professional development activities since 2000. These activities focus on schools and classroom activities, in view of the evidence of the low impact of workshops held without a clear connection with math and science teaching practice.

Given that teacher training is one of the factors that most influence the academic outcomes of students (Cochran-Smith & Zeichner, 2005) and elementary school teachers rarely have specific training in any of the areas of STEM, Little Scientists has developed a framework for the professional development of in-service teachers, which encourages teachers to approach scientific knowledge through inquiry and research strategies that can be transferred to the teaching and learning process in the classroom.

Little Scientists proposes a professional development strategy based on the learning by inquiry approach (National Research Council, 2000). This training is developed from a perspective of situated learning (Putnam & Borko, 2000), in authentic contexts and focuses on the development of the didactic knowledge of the discipline, enabling teachers to not only understand the ideas to teach but also to learn the most appropriate strategies for ensuring that their students learn (Shulman, 1986).

Evaluating both students and teachers is the most effective way of improving teaching and learning in the areas of science, technology, engineering and mathematics. The framework for the assessment is based on the description of the knowledge expected of competent students in natural sciences and describes different types of cognitive achievements. The goal of science learning is for students to develop declarative knowledge (factual, conceptual), procedural knowledge (step by step, condition-action), schematic knowledge (explanations) and finally strategic knowledge (problem solving and validity of reasoning) (Li & Shavelson, 2002; Shavelson, Ruiz-Primo, & Wiley, 2005).

Promoting this type of learning at school is achieved through the intentional work of teachers, which is why Little Scientists has designed a framework for inquiry-based science and technology education. This framework defines the aspects that should be taught in science and technology and reflects the state of the art in teaching approaches for science education (Duschl, Schweingruber, & Shouse, 2007). Little Scientists identifies four aspects of science teaching:

Conceptual schemes, linked to the construction of scientific, technological and mathematical ideas and their appropriation by students.

Process strategies, which involves teaching students to do science, technology and mathematics, formulate questions and predictions, construct hypotheses and validate their conclusions;

Epistemological frameworks, in which student are expected to approach the nature of scientific and technological knowledge, such as recognizing the impermanence of ideas and conclusions and the validity of evidence-based knowledge.

Lastly, it includes an aspect of social processes related to communication, language and the arguments of science, mathematics and technology.

Transforming the teaching-learning processes of STEM areas in elementary education in Colombia forces us to reflect on the science and math curriculum, and change the approach to what is taught and learned in the classroom. The fact that Colombian schools have curricular freedom oriented by national guidelines and standards makes it possible to replace long lists of contents with a less extensive curriculum, focused on the development of major ideas in science, mathematics and technology (Harlen, 2010), in situations of diverse and productive learning (Worth et al., 2009).

These frameworks are based on the conviction that genuine transformation requires the involvement of different actors in the community, including parents, school administrators, teachers, local decision makers and the productive sector.

Promoting transversal skills in language and mathematics has been present in the management of classroom protocols. Math teaching materials proposed by PREST-Canada to begin a STEM-based initiative are currently being adapted.

In 2007, in order to serve the IBSE community of the Academies of Latin America, through an agreement between the Academies of France, Brazil, Argentina, Chile, Colombia, the University of the Andes and the Secretariat of the Andrés Bello Agreement, the Latin American portal Indágala (initially Map America) was created on the "MAP Monde" platform, donated by the French Academy of Sciences. This agreement was expanded to include the other academies in the IANAS Education Program. The platform was administered by the University of the Andes. In 2011, Indágala began to be mounted on the hardware of the Mexican Academy of Sciences and in 2012, it was decided to transfer the entire Portal to the Mexican Academy of Sciences, by which it is currently administered.

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3.5 The case of Mexico[8]

The Mexican education system includes three years of preschool, six years of elementary school and three years of middle school, comprising compulsory basic education. This is followed by three years of high school before students can pursue higher education studies. There is an official curriculum teachers must cover in its entirety. Mexico has consistently occupied the lowest positions in the OECD evaluations at different times. After analyzing the situation, Dr. José Antonio de la Peña and Dr. Carlos Bosch Giral, from the Mexican Academy of Sciences, decided to focus on in-service teacher training. Accordingly, in late 2001 and early 2002, they convened a group of 20 scientists and education specialists to analyze international science education proposals and the particular situation of science teaching in Mexico. For several months, the group focused on designing, justifying, structuring and organizing a program whose objective was to improve students' and teachers' attitude towards science and math. All the work targeted the country's basic education teachers, regarded as the cornerstone of education.

In mid-2002, the Science at Your School (SYS) Program emerged as a response by the Mexican Academy of Sciences (AMC) to support science and math education. Dr. Carlos Bosch was appointed as the program's academic coordinator. Study materials were designed, anthologies of readings compiled and a website set up as a permanent forum for consultation and discussion, in keeping with the Public Education Secretariat (SEP) programs and curricula. With the support of the Under-Secretariat of Educational Services for the Federal District and the Under-Secretariat of Planning and Coordination, on August 24, 2002, the "Science at Your School" Diploma Course was launched for 5th grade elementary and 2nd grade middle school teachers from 68 basic education schools in the Federal District. Students were invited to participate to support the participating teachers' classroom work and serve as a link between these teachers and scientists.

The diploma course is divided into four modules: Math, Science 1, Science 2 and History of Science; with 32, two-and-a-half hour Saturday sessions for a duration of 80 hours. Complementary Computer and English workshops are offered.

The initial group directing the Science at Your School Program evolved, incorporating basic education teachers and assessment specialists. Since the contributions of both groups are essential to steering the work, it was decided to redesign the high school program and tailor it specifically to teachers at that level: the History of Scientific Ideas module was preserved, and a general Science module (Physical Biology, Geography, Mathematics and Chemistry) added, together with a specialization module in each of the above areas. Lastly, after a number of adjustments, the work modules were organized as follows:

Elementary modules	
Mathematics	8 sessions
Science 1	8 sessions
Science 2	8 sessions
Communication Skills Development	6 sessions
Middle School Modules	
General Module (Mathematics, Physics, Chemistry, Biology and Geography)	12 sessions
Specialty Module	12 sessions
History of Science	4 sessions
Communication Skills Development	2 sessions
In both cases, the program is accompanied by a computer workshop and consists of 180 hours.	

The diploma course was also open to teachers of any elementary or middle school grade. Despite our initial aim of working with teachers from grade 5 of elementary school or grade 2 of middle school in order to follow up on their students, it proved impossible to locate these students in their following courses.

8. **Carlos Bosch**, Focal Point Mexico, member of the Mexican Academy of Sciences, professor at the Autonomous Technological Institute of Mexico (ITAM). **Silvia Romero** and **Carmen Villavicencio** of "La Ciencia en tu Escuela".

From the second generation, onwards, an evaluation process was begun to measure teachers' and students' attitude towards mathematics and science. Instruments were also designed to evaluate the modules and speakers and knowledge tests designed for the students of participating teachers and the teachers themselves. Video recordings were also made in some classrooms of the participating teachers in order to observe teacher-student and student-student interaction, and see whether the proposed materials and teaching styles worked properly in the classroom.

Teachers also requested assistance with writing. They were initially offered a writing workshop, for which demand steadily increased, until it played an important part in this diploma course at both the elementary and middle school level.

The teacher training proposal has been shared and implemented in seven states: Baja California Sur, Guanajuato, Puebla, Morelos, Michoacán, Yucatán and Quintana Roo to support teachers outside the Federal District.

The program was presented to the Academies of Sciences of the United States and France. An exchange agreement was signed with France's La main à la pâte program and the program's website was incorporated into the ICSU/IAP portal.

As a result of the degree of acceptance of the Science in Your School diploma course, the group that runs it (a group of scientists together with in-service teachers and evaluation specialists) called the Teaching Group, decided to teach it to teacher training colleges. The material available to date has therefore been adapted to be to taught at the Benemérita Escuela Nacional de México (BENM) (BENM) in four modules: Math, Science 1, Science 2 and History of Science; with 52, two-and-a-half hour evening sessions for a duration of 104 hours.

For middle school, the program was adapted for the Escuela Normal Superior de México (ENSM) in three modules: History of Scientific Ideas, General Science Module, Specialization Module with 52 two-hour evening sessions for a duration of 104 hours. However, in this endeavor, despite changing the method and the materials a couple of times, we failed to achieve the desired success because the student teachers were very young, with no teaching experience and since the program was not compulsory, they lacked the necessary commitment. The work at the teacher training colleges lasted three years, during which we were not even able to keep track of the teachers who had participated in the program since they were assigned to different schools of which we were not informed.

It is interesting to note that in 2004, the program was invited as an observer to participate in the Education Program of the Inter-American Network of Academies of Science (IANAS SEP). The following year, Science at your School participated as a member of IANAS SEP and since then has not stopped participating in these meetings, and has already hosted these meetings three times.

In 2005, we were asked to implement the program in collaboration with the National Council for Educational Development (CONAFE), to support community elementary and middle school instructors in rural areas of Acapulco, Chilpancingo, Iguala, Ciudad Sahagún, Pachuca, Tulancingo, Metepec, Querétaro and Tlaxcala. The program has had an enormous impact. CONAFE directors have undertaken measurements and students of teachers who participated in this diploma course obtained results in the Enlace (National Assessment of Academic Achievement in Schools) Examination organized by the Public Education Secretariat that are very close to the national average and well above those of students in these rural areas whose teachers have not participated in the Science at Your School Program.

As a result of the IANAS-SEP meetings, several Latin American countries participate in activities organized by the Science at Your School Program and in 2007, a collaboration agreement was signed with the academies of sciences of Bolivia, Colombia, Costa Rica, Guatemala, Panama, Peru and Dominican Republic to set up a similar program in these countries and support existing programs.

In 2008, two events marked the Science at Your School Program. First, through support from the National Council of Science and Technology

(CONACYT), funds were obtained for the first external evaluation of the program in face-to-face sessions by the educational consultants Grupo VALORA. A detailed study involving interviews with the teachers and student teachers of all ages who had taken this diploma course until then yielded a report showing the methodology used, and the change in attitudes and knowledge of the teachers and students who had participated in the diploma course compared with a control group. In short, we can say that a lesson well learned is not forgotten; the evaluation highlights some of the achievements of this diploma. This external evaluation marked a watershed in the program because it provided the evidence needed to convince many skeptics of the benefits of this type of teaching. Since 2009, the program has had consistent support from several institutions which, although not enough to enable the program to grow by leaps and bounds, have ensured its continuation despite political changes. That same year, materials began to be produced for distance learning so that the material could reach remote locations where there are no scientists to provide direct support for teachers. In 2010, the first Science at Your School distance learning program was completed by teachers from Coahuila, Mexico City, Durango, the State of Mexico, Guanajuato, Jalisco, Morelos, Nayarit, Nuevo León, Oaxaca, Quintana Roo, Sonora, Tamaulipas, Tlaxcala, Yucatán and Zacatecas. At that point, the SEP conducted an assessment, whose results were sufficiently encouraging to make us continue the program, with a number of refinements and improvements. The 2015 cycle saw the participation of several teachers from Latin America, including 14 from Peru, Venezuela, and Colombia who completed the General Elementary School Diploma Course and 38 teachers from Guatemala, Colombia, Venezuela, Peru, Bolivia, Nicaragua and the Dominican Republic who completed the General Middle School Diploma Course.

The Science at Your School Distance Learning Program now has a diversified supply of teacher training for elementary and middle school teachers: seven diploma courses and five courses to promote teachers' professional development.

Evaluations of Science at Your School

We understand evaluation as a process of assessing compliance with the purposes of this compensatory educational intervention program, in which tools with a qualitative and quantitative approach are incorporated to measure achievements and take appropriate decisions for the continuous improvement of the training of the teachers involved. The strategies and processes developed by the teaching group for this purpose contain quantitative and qualitative elements which may be analyzed to issue well documented reports on what this program means for the students of participating teachers.

As happens every year, in 2015, various quantitative assessments were undertaken to measure teachers' attitudes towards math and science and each of the modules and speakers in the program's two modalities were evaluated.

SIEC was used to streamline the recording of the information from the questionnaires to evaluate the face to face diploma and analyze the information in less time. This system enables participating teachers to undertake the evaluation on line, immediately obtain the information for analysis, automatically compare the group results with the overall sample of each of the modules and present the information in the form of graphs.

These external evaluations conducted in 2009 are available at: http://www.lacienciaentuescuela.amc.edu.mx/?q=secciones/presencial/evaluacion.html

In the distance mode, the evaluation survey is integrated into the work platform for participants to complete at the end of each course. This enables the information to be analyzed to provide feedback to the consultants and identify areas for improvement. The results make it possible to modify the courses, restructure them and produce new support resources if necessary. It also makes it possible to analyze what teachers think about the work platform and determine their degree of satisfaction with the educational modality. In addition to these instruments, students and advisors are tracked by school administrators. An analysis is conducted of the records, the activities undertaken and the degree of participation in the platform.

In the last quarter of 2015 and, as a results of a bidding process that was consolidated through a cooperation agreement with the United Kingdom through the Newton funds, the external evaluation process began to be conducted of the Science at Your School distance mode. The study, conducted by the CollaboratED and UKEdChat group, with the support of the British Council and the Newton funds, began with a meeting of all those involved in the process to enable experts to understand the context and objectives of Science at Your School at a Distance and to jointly develop the assessment protocols for the content, platform and user experience, agree to the scoring systems and develop an action plan for the study. The results of the external evaluation program will provide the program with elements for making decisions on future actions.

The various assessments, including this last one, as well as more detailed information on the face to face and distance learning program, are available at: http://www.lacienciaentuescuela.amc.edu.mx/

3.6 The case of Chile[9]

Beyond mathematics, science education in Chile has received scant attention. Throughout much of the 1980s, the teaching of chemistry and physics in middle school was not compulsory. Education in the experimental sciences in the vast majority of schools and colleges in the country is still theoretical since nearly all of them lack properly equipped laboratories. Moreover, in their initial training, teachers are not taught enough about setting up experiments and demonstrations or designing practical protocols.

In 2000, under the leadership of the US National Academy of Sciences, the Royal Society in the UK and the Science Council of Japan, all the National Academies of Science were invited to meet in Tokyo, Japan to take advantage of the start of the new millennium and look to the future. The target date was 2050 and it was decided to study the major challenges that the world's sustainability posed for science.

The title of the conference was "Transition to Sustainability" and it was inaugurated by the Emperor of Japan. Dr. Jorge E. Allende was invited to speak at the session on Science Education and the Chilean Academy of Sciences, which appointed him as its representative. At the Tokyo meeting, a new institution was set up, the InterAcademy Panel (IAP), which currently brings together 105 National Academies worldwide and is headquartered in Trieste, Italy. The Science Education Session involved the participation of: Dr. Bruce Alberts, the then President of the US National Academy of Sciences, French astrophysicist Pierre Lena on behalf of the French Academy of Sciences and molecular biologist Dr. Jorge E. Allende.

Dr. Allende spoke mainly about the need to erase the appalling image children tend to have of scientists, using the example of an experiment

9. **Jorge E. Allende Rivera,** Focal Point Chile, member of the Chilean Academy of Sciences and Professor of the Faculty of Medicine at the University of Chile.

conducted by Brazilian biochemist Dr. Leopoldo de Meiss in which children from many countries were asked to draw a scientist (Leopoldo de Meis, Ciencia e Educação: o Conflicto Humano-Tecnológico, Río de Janeiro, 1998). These drawings were very negative since they depicted men with sinister expressions torturing animals or exploding bombs. No women scientists were shown and in Southern African countries, all the scientists drawn by the children were white.

For Dr. Allende, the highlight was the presentation by Alberts and Léna on how Inquiry-Based Science Education (IBSE) had been adopted in the US and France, and how the results obtained through this method had been extraordinarily positive, since children were thrilled to learn scientific concepts by doing experiments. Moreover, this approach has the advantage of allowing scientific institutions to play a key role in enabling children to learn and enjoy science. At that moment, Dr. Allende was convinced that everything possible should be done to introduce the IBSE approach to Chile. He immediately contacted Bruce Alberts and Pierre Léna to plan visits to the United States and France to observe the method firsthand.

On a trip to Washington a few months later, Dr. Allende visited the Smithsonian Institute where he met Douglas Lapp and Sally Schuler; who headed the National Science Resource Center (NSRC) which served as the headquarters of the US IBSE Program. They gave him the teachers' and students' books detailing the science teaching models used to teach children the basic concepts of science that had very simple titles such as Properties of Matter, Food Chemistry, Float or Sink, Climate and so on.

Each of these modules had a kit of very simple materials used in classrooms so that children could do experiments to demonstrate the concepts taught. On that visit, Dr. Allende secured a promise from Drs. Lapp and Shuler to visit Chile to implement the use of these modules as soon as possible.

On the other hand, through correspondence with Pierre Léna he learned that in 2001, the Pontifical Academy of Sciences was organizing a meeting at the Vatican to discuss science education. Dr. Léna, who is a member of that Academy, invited him to the meeting.

Back in Chile, Dr. Allende shared these details with Dr. Devés Rosa, who had served as Assistant Director of the Institute of Biomedical Sciences, of the Medicine Faculty when he was its first director, and was working at the Curriculum Unit of the Ministry of Education. She had been at school with Mariana Aylwin, the Minister of Education appointed by President Lagos. Rosa Devés was extremely interested in this new method of teaching science and together with Dr. Allende worked to convince Minister Aylwin that Chile should adopt this method.

That same year, 2001, the Ministry of Education was persuaded to sponsor a UNESCO Participation Program to finance a meeting of Academies of Sciences to be held in Chile in January 2002. The meeting was to be attended by the US team to demonstrate the use of the IBSE method. Dr. Pierre Léna of the French Academy of Sciences and Guillermo Fernández de la Garza of Mexico, who was introducing this method into that country with US support, had translated the modules into Spanish. Prior to this Dr. Allende had participated in the meeting at the Vatican, which was extraordinary because he stayed at Domus Marta, where the Cardinals are housed. The meeting was also extraordinary, the most important aspect being the demonstration of the "Float or Sink" module in which groups of participants did what children in the fourth grade of elementary education do. Dr. Allende participated in a group with the German Physicist Mössbauer, the Nobel Physics Laureate in 1961 and Permanent Secretary of the French Academy of Sciences. The scientists had as much fun as kids watching and making predictions about whether an object would float or sink in a tray of water. Suddenly, Dr. Allende noticed that his group's results differed from those of the neighboring group, which was explained when Dr. Mössbauer put his finger in the water to taste it, after which he burst out laughing and said, "They even cheat at the Vatican," because the water in the tray they were using contained a large amount of salt. (The presentations at this meeting were published in the book of the Pontifical Academy Scientiarum, *The Challenges for Science Education for the Twenty-First Century*, Vatican City, 2002. ISBN 88-7761-080-8)

The meeting in Chile in January 2002, at which the demonstrations of the Smithsonian modules were repeated with the help of the NSRC group, was very successful. At a luncheon hosted by the Ministry of Education, when Professor Léna learned Minister Aylwin was going to Paris to a UNESCO meeting, he promised her a visit to a school in Paris where the "La main à la pâte" Project was being implemented. This visit convinced the minister of the enormous impact this method had on children, since it enabled them to enjoy learning science. Pierre Léna recently published a book chronicling this visit and its effect on Chile. (Léna Pierre, *Enseigner, c'est espérer: plaidoyer pour l'école de demain*. Collection: "Essais-Les défis de l'education", Broché, Paris, 2013, Edition Le Pommier, ISBN 97827465062751)

At the same time, the Smithsonian group invited the Chilean Ministry of Education to send a group of scientists and educators to attend a strategic planning workshop (LASER Workshop), which trains teams in the new educational districts that are going to introduce the inquiry-based method. Fortunately Rosa Devés agreed to lead this group, which made good use of the visit made in July 2002.

Meanwhile, Dr. Allende drafted a project for the Andes Foundation for a total of $100,000 USD, which contributed 50% of the cost of a pilot project to begin introducing the IBSE program into Chile at six schools in Cerro Navia (a disadvantaged neighborhood near the airport) with the "Properties of Matter" and "Food Chemistry" modules for levels 6 and 7 of elementary education. Cerro Navia was chosen because the Mayor of that Municipality, Cristina Girardi and her Director of Education, Santiago Aranzaes, placed a high priority on improving the science education standards in that township. The project was approved by the Andes Foundation and also by the Ministry of Education, which contributed an additional $100,000 USD in funding, which was a requirement for the Andes Foundation.

In November 2002, Rosa Devés, Patricia López Stewart and Elizabeth Liendro, who had accompanied Rosa to Washington, organized a training session for teachers who would act as monitors in the implementation of the project and in January 2003, this group trained the teachers in Cerro Navia, including the school administrators and UTP (Technical Teaching Unit) directors at the six schools. Samples of the modules to be used had been sent from Washington and it was not very difficult to replicate those materials by purchasing them in Chile.

So it was that in March 2003, only two and a half years after Dr. Allende had found out about the inquiry method at the Tokyo meeting, it had been set up in public schools in an at-risk population township in Chile.

The impact of the implementation of this project on the children, teachers and school administrators was immediate and extremely powerful, since within a few weeks, science classes became the source of a great deal of conversation, activity and discussion. The children enjoyed the experiments and teachers were surprised at their students' interest and what they wrote in their science notebooks when they described what they had learned. Parents were also surprised when their children in that municipality, among the poorest in the metropolitan region, told them they were the first children in Chile who were learning with the methods and materials used in the United States.

Pressure was rapidly mounting to increase the number of modules to 8th grade of basic education and 5th grade, with the entire second cycle of basic education being covered in 24 schools in 2004. By 2005, Pedro Montt, Director of General Education, asked for the method to be extended to the entire 1st cycle of basic education. In 2005, the Ministry incorporated IBSE as an experimental initiative, combining it with the RWM (reading and writing and math) experience.

The Metropolitan Region Program in the townships of Cerro Navia, Pudahuel and Lo Prado was implemented under the leadership of the Medicine Faculty at the University of Chile. In 2005, schools in the 5th Region were incorporated under the supervision of the University of Playa Ancha with the support of the Santa Maria University, while those in the 8th Region were incorporated under the supervision of the University of Concepción. In 2006, the University of La Serena were incorporated into the scheme, and asked to supervise the 4th Region, together with the Universidad de la Frontera, tasked with the 9th Region and the University of Talca, which assumed responsibility for the 7th Region with a total of 94 schools. In 2009, 12 universities participated in 250 schools in the 15 regions of the country with 100,000 children learning science through this method.

In 2008, the Ministry of Education commissioned an evaluation of the IBSE Project by the Pontifical Catholic University of Valparaíso, with a team led by Dr. Carmen Montecinos, who was advised by three prominent international experts: Professor Wynne Harlen from the UK, Professor Pierre Léna, Director of "La main à la pâte" Program in France and Professor Patricia Rowell from the University of Alberta in Canada. The results of this evaluation were extremely positive.

Another important result of the Chilean IBSE Program is that it was used to train groups in Venezuela, Peru, Bolivia and Panama, which launched similar projects.

The success of the Chilean project prompted the IAP to ask the Chilean Academy of Sciences to assume the worldwide leadership of this project, appointing Dr. Allende as Coordinator of the Global Project. Between 2007 and 2009, we were able to secure an Organization of American States (OAS) project for the Americas, which was also coordinated by Dr. Allende, and which invested $300,000 USD in disseminating the IBSE project in Latin America during the period 2007-2009. (Allende, J. *Academies Active in Education Science*, 2008: 321:1133)

These links allowed us to organize numerous meetings and conferences in Chile with leading international experts.

On February 27, 2010, Chile suffered a devastating earthquake and tsunami that caused many casualties and enormous material damage. Two weeks later, a new government came to power, which said that the country could not continue funding the IBSE program, in which 12 universities and the Academy of Sciences had participated. It unilaterally decided to rescind the agreements it had signed with the universities and drastically reduced the budget from the ministerial contribution, which was just over $1 million USD.

Despite the withdrawal of support from the Ministry of Education, the IBSE Project of the University of Chile under the leadership of Rosa Devés and Pilar Reyes managed to maintain a small group to implement the project at 39 schools until 2014, receiving input from municipalities, mining companies (Anglo American) and the ALMA Observatory. Active groups continued to operate at the University of La Serena and Universidad Austral de Chile in Valdivia. The Municipality of Concepción adopted similar measures.

The good news is that in March 2014, a new government took office with the promise of improving education at all levels. A few months later, the new authorities received a proposal from the Chilean Academy of Sciences and the University of Chile to rebuild the IBSE Programme and resume working with a network of universities. This has resulted in the establishment of a working group involving the Ministry, the Academy and 14 Universities. For 2015, this Working Group has proposed the organization of a National Diploma Course Program to train teachers in the inquiry method (ICEC Project) at the nursery, elementary and middle school level. We hope this will result in a revival of the Inquiry Project.

Portable Lab Project for Teaching Molecular Biology in Middle School Education

The Latin American Network of Biological Sciences (RELAB), which has 15 member countries, began in 1975 based on a UNDP-UNESCO project focused on strengthening graduate programs in biological sciences in Latin American countries. At the end of the last century, it found that there was a great need to train middle school teachers in the areas of molecular biology, since although it was being incorporated into the curriculum, they had not been trained in it.

After organizing several theoretical and practical courses to train middle school biology teachers, we realized that the trained teachers had learned a great deal from these courses yet were frustrated because they were unable to share the most educational and entertaining part of the course: the experiments. To solve this problem, RELAB sponsored the application of three member countries supported by their main state universities: Mexico with UNAM, Costa Rica with the University of Costa Rica and Chile with the University of Chile and the Wellcome Trust in the United Kingdom, which in 2011, had a program to communicate the advances in life sciences to society. The project proposed the organization of three theoretical and practical courses, one in each country, to train middle school biology teachers in key molecular biology and genomics concepts. The difference with what had been done previously was that the project also financed the purchase of three portable laboratories, one for each country. These portable laboratories included all the instruments and materials required so that groups of 30 students could perform the same experiments as the teachers had done at the university.

Middle school teachers who pass the course undertake to teach the theoretical classes they received during the course and request a visit by the portable laboratory to their school. Portable laboratories come to the high schools accompanied by two graduate students in molecular biology, who help the teacher set up the experiments and discuss the results with students.

This project was approved by the Wellcome Trust 2012. That same year, courses for middle school biology teachers were organized in the three countries with a similar format, focusing on the teaching of four fundamental concepts:

1. The characteristics of the species and individuals of all living beings are defined by the genetic information written in the sequence of nucleotides in their genetic material.
2. The genetic information of organisms is regulated by intra and extra cellular signals that turn the expression of specific genes on and off.
3. The genetic code that defines the translation of the information written in the nucleic acids in proteins encoded by genes is practically universal and the mechanisms used by all living things to translate that information is very similar. This concept makes genetic engineering possible, since virtually all living beings are capable of correctly translating a genetic message from another very different species.
4. The Darwinian evolution of living species can be studied by analyzing the gene sequences or proteins encoded by those genes that perform similar functions in different species. The more distant species are in the evolutionary process, the greater the number of mutations that will be detected between genes that perform similar functions in different species. The science that focuses on their analysis is known as evolutionary genomics.

The theoretical part of the intensive courses for teachers teaches the history of the ideas of the researchers who developed these four key concepts. The practical part of the course includes conducting experiments to demonstrate the validity of these four concepts.

Between 2013 and 2015, these teachers' courses have been given annually in the three countries and various middle schools have been visited. Twenty-five middle schools have been visited in Chile. These visits have enabled approximately 750 high school students to perform sophisticated experiments using the instruments and materials in the portable laboratories. The amount invested in the portable laboratory was $10,000, equivalent to spending $13 USD per student benefited, which is considerably less than the price of a molecular biology text for each student.

In this pilot phase, we collected the views of the three groups that have been directly involved in this teaching innovation: middle school biology teachers who have passed the course and received the visit of a portable laboratory and high school students who have used the portable laboratory to perform sophisticated experiments that teach the fundamental concepts of molecular biology. These views are available at the following website: www.laboratoriosportatiles.cl in the opinions tab. As one can see, the responses to this consultation have been virtually unanimous in regarding this innovation as extremely positive in facilitating learning and making science teaching more attractive and entertaining.

These results have encouraged us to scale this project in various ways. On the one hand, the 2016 project is already working in three other countries: Brazil, Uruguay and Panama, which have portable laboratories, have given the teachers' course and are beginning visits to middle schools.

We are also increasing coverage of the biology topics included in the middle school curriculum and have theoretical and practical modules designed to teach the chapters on "Proteins and Enzymes" and "Fertilization and Early Development of Animal Embryos." In 2016, we plan to increase this number in another module.

Lastly, in 2016, the program will be significantly scaled nationwide in Chile with the support of the Ministry of Education. This scaling will involve eight new universities, which will be visiting middle schools in seven of the 15 regions of Chile.

We think that in the future, the use of portable laboratories should be increased to cover all the teaching of experimental sciences, including not only biology but also chemistry, physics, astronomy and earth sciences. This will not only require the participation of the Academies of Sciences but also the Network of Discipline-Based Institutions, which, like RELAB, are involved in the promotion of one of the experimental sciences.

3.7 The case of Panama[10]

Inquiry-Based Science Education arose in Panama to improve science teaching through the inquiry strategy. It was implemented by the National Secretariat of Science, Technology and Innovation (SENACYT) through an agreement with the Ministry of Education. During the period 2006-2009, 2,500 teachers were trained and accompanied at 120 schools, equivalent to approximately 17% of elementary school students. The scheme included the participation of a group of facilitators, mostly middle school science teachers, who worked full time accompanying teachers during the planning and development of classes and providing them with feedback on the points to be improved based on observation guidelines. This process was undertaken over a period of four months of the school year for each teacher. Most facilitators underwent a one-year, full-time training period with practices at schools and workshops provided by international experts. The schools used modules developed in the United States and translated into Spanish, with twelve to fifteen classes per subject. Teachers continued with the national programs, trying to implement some of the strategies proposed by the facilitators. After the change of government in 2009, the project was incorporated into the Ministry of Education, which changed the approach used for science teaching. The facilitators returned to their middle school classrooms and only one group of ten facilitators continued to give workshops at schools on request.

Assessment

In 2008, a team, led by an international evaluation specialist, measured the program's impact on

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the children's learning. A test was designed with questions focusing on the modules developed and the national curriculum content. A pilot test was conducted, with items that failed to discriminate being discarded. A total of 19,177 students, 12,856 from the program and 6,321 from the control group, corresponding to 927 teachers from 118 public schools in nine educational regions, were evaluated. The results showed a positive, statistically significant impact in 3rd grade. An improvement was observed in both the questions on the material in the modules and the curriculum. In 4th and 6th grade, learning impact was positive but not statistically significant. The impact was negative, although not statistically significant, for the official curriculum material in 6th grade. The sample made it possible to obtain information on the program's impact by province, facilitator and teacher. One interesting aspect observed was the close link between students' results and the quality of the class registered through the observation guidelines.

Current status

There are a number of factors affecting the teaching-learning process that take place in the classroom, one of which is the syllabi. It is important for what is to be taught and how it is to be taught to be reflected in the national curriculum. On the basis of an analysis of our programs and international curriculum trends, the Ministry of Education and SENACYT have defined children's Fundamental Learning Rights and the conceptual progressions and scientific skills to be developed at Panama's elementary schools. On the basis of these contents, with the help of previously trained facilitators, classroom materials are being developed, previously developed professional development sessions are being resumed, support is being provided to schools on request and Diploma Courses are being offered by local universities to strengthen teachers' scientific knowledge of teachers and science teaching. In 2017, a national assessment will be conducted of mathematics, language and science which will enable more appropriate actions to be taken.

3.8 The Case of Costa Rica[11]

In Costa Rica, inquiry-based science education began in the first and second cycles of primary education, as an initiative of the Ministry of Public Education (MEP), with the support of the National Academy of Sciences of Costa Rica. In 2009, a pilot program coordinated by the National Science Advisor of the Department First and Second Cycles of the Directorate of Curricular Development was implemented. This diagnosis highlighted the need to train teachers to link pedagogical mediation to scientific research processes in keeping with the age of the student body. The teachers participating in this process made it possible to lay the groundwork for the implementation of inquiry-based methodology for the Costa Rican context.

11. **Viviana V. Carazo**, Focal Point Costa Rica, research professor at the University of Costa Rica.

Accordingly, in 2009, the National Advisory Board for the First and Second Cycles of Elementary Education, with the support of the National Academy of Sciences of Costa Rica, the "La main à la pâte" (LAMAP) Program of the French Academy of Sciences, the Mexican Academy of Sciences, the Chilean IBSE Program and the young Scientists Program of Colombia, among others, published three modules for Inquiry-Based Science Education:

- **Module 1: Inquiry in science education:** This is proposed as the starting point for taking a different way of teaching science in elementary education into the classroom, through teaching. Module 1 explores the philosophical and epistemological approach to Science Education, the organizational perspective concerning the participants in scientific education, methodological approaches and the

IBSE methodology and curricular approach. The document concludes with a list of general guidelines for the science programs for Cycles I and II of Basic General Education (MEP, 2009a).

- **Module 2: Planning and pedagogical mediation using an inquiry-based science education approach:** This module is intended to provide information to teachers of the first and second cycles of elementary education, to implement this pedagogical mediation approach to classroom teaching, by providing guidelines for asking questions, exploring previous ideas, the atmosphere of educational contexts, socialization and communication, lesson planning and the role of the teacher and the student (MEP, 2009b).
- **Module 3: Teacher training based on the methodology of Inquiry-based Science Education:** guide for promoting professional learning. This was drawn up on the basis of the text "Action-research for the Continuing Education of Educators" by Alejandrina Mata (2007) San José: INIE/UCR. This module, designed for teacher trainers, presents a flexible strategy oriented towards promoting meaningful, contextualized learning, in order to transform science teaching in Cycles I and II of Basic General Education (MEP, 2009c).

During the second stage, in 2010, the national strategy for the implementation of Inquiry-Based Scientific Education was defined through an agreement between the MEP and the National Council of Rectors (CONARE), which facilitated the training of teachers from four public universities and the 27 Regional Science advisors, to form train the trainer teams, which, in coordination with the National Science Advisory Board and the Professional Development Institute trained approximately 16,000 teachers in the first and second cycles of the country in 2011. This program was implemented during the period 2010-2012 in 90% of schools offering the first and second cycles of Basic General Education in all the country's educational regions.

Science Programs in the first and second cycles of primary education were published in 2012, incorporating the theoretical and operational benchmark for inquiry-based scientific education that Costa Rica had been implementing for years.

Subsequently, in 2014, the Higher Education Council, through the 03-15-2014 Agreement, approved the publication of the programs for the First and Second Cycles of Elementary Education with the incorporation of the inquiry-based approach into learning situations. These programs have continued to be implemented.

Since 2012, the National Advisory Department First and Second Cycles MEP Sciences has implemented strategies to provide support, monitoring and evaluation of the implementation of the research methodology in various educational regions. Processes have been developed that include reinforcement courses and refresher workshops designed for both teachers and counselors who have expressed the need for inquiry-based methodology training. Likewise, support and feedback regarding teaching have been provided through visits to samples of schools within the Regional Education Directorates. As part of this monitoring process, in 2015, a refresher course designed for Regional Science Advisors nationwide was developed with the support of the French Embassy.

The development of the inquiry-based education program in the context of Costa Rican public education is designed to promote the construction of scientific, technological and social thought, seeking to integrate *"cognitive and socio-affective aspects and allowing the formation of skills, attitudes and values such as: asking questions, observing, recording, analyzing and communicating results, working collaboratively, honesty in data collection and information use, criticism and willingness to establish consensus, among others, in keeping with the age of the student"* (Calderón and Hernández, 2015: 1).

The *"Inquiry-Based Education Program of Scientific Thought ... seeks a change in the way science is taught and learned to make it reflexive and experiential, which will permit the development of scientific thinking in children in cycles I and II. This is designed to promote scientific skills from children,* *by encouraging a taste for science and technology, by "thinking, doing and communicating"* (Calderón and Hernandez, 2015: 1). As part of the activities in this program, the Department of Curriculum Development in the Department of Cycles I and II is responsible for the continued training of academic and administrative stakeholders in the education system, which have an impact on science education at these levels. It considers the construction of teaching materials under this approach, the sharing of experiences of good practice and the systematization of classroom processes for monitoring and evaluation to provide feedback on the theoretical and practical aspects implemented by teachers (Calderón and Hernández, 2015).

At present, through the inclusion of the inquiry-based approach into the Science Curricula Science for Cycles I and II 2014, approved by the Board of Education, which is being implemented in the 2016 school year, IBSE as a national policy for science teaching has been adopted at all primary education schools in the country.

New Focal Point for Inquiry-Based Science Education and Teaching

In the second half of 2014, the National Academy of Sciences of Costa Rica (NAC of CR) changed its Focal Point in Education. This transition has led to the proposal of new challenges and objectives in the quest to promote and enhance Inquiry-Based Science Education (IBSE). Work currently focuses on the proposed approach and strategies for achieving this goal, with the administrative support of the NAC of CR.

It is thought that in order to promote and enhance IBSE for the NAC of CR, it is essential to establish forms of joint, coordinated work with both the Ministry of Public Education (which has declined in recent years) and the main institutions responsible for preparing teacher educators. This is the first objective to be achieved by the Focal Point in Education.

To this end, and after an analysis of the Science Curriculum, from the preschool level to diversified education (10 and 11), it is clear that the approach to teaching in Costa Rica is undergoing major changes. This has begun to be reflected in the rationale and structure of the new preschool education programs, whose current program focuses mainly on *"the development of all the potential and interests of our children, while also meeting their biological, emotional, cognitive, expressive, linguistic and motor needs through a comprehensive pedagogical approach. This combines actions for addressing the psychomotor, cognitive and socio-affective processes that promote self-knowledge, the gradual development of autonomy, respectful interaction with others, the body's possibility for action, hand-eye coordination, executive functions, linguistic life skills, the inclusion of phonological awareness, the enjoyment of children's literature and in general, the ability of every child to act within their physical and social environment and understand the meaning of their actions."* (MEP, 2014: 8).

The science curriculum of Cycles I and II of Primary Education (MEP, 2014) considers the contributions of neuroscience, among other aspects, through the promotion of the integral formation of students, indicating that, *"It is necessary to incorporate innovative proposals to promote teaching practice and consider the harmony between the brain, learning and human development for the construction of significant learning by students"* (MEP, 2014:11). In fact, the fundamentals of this curriculum, which contemplate philosophical, sociocultural and historical, educational, artistic and linguistic aspects include the ecological foundation, which highlights the importance of understanding that *"the environment comprises experiences that promote awareness, respect for biodiversity, love of nature and the interdependence between socio-cultural, economic and natural aspects"* (MEP, 2014:16). Demonstrating an important evolutionary process, this curriculum now includes neuroscientific and psychobiological foundations as the basis for considering the importance of the relationship established between an organism that learns and its environment, while realizing that pedagogical mediation is essential to harnessing and developing individual capacities. This curricular perspective is expected to begin to permeate the educational programs of subsequent cycles.

In fact, in the context of curricular reforms, the syllabus for the third cycle of science (MEP, 2012) indicates that, *"the changes incorporated into these programs for the teaching and learning of science as a social activity are part of an issue of vital importance for human training: affectivity and sexuality, in which learning combines elements of knowledge and scientific inquiry-natural, psychological and social-with elements of sensitivity and respect that should always characterize human relations, coexistence and our mutual understanding"* (MEP, 2012: 3).

It is this fact, coupled with the global trend in the use of neuroscientific knowledge as the basis for understanding and implementing consistent pedagogical mediations in keeping the process of human neurodevelopment, that led to an agreement between the ANC and the University of Costa Rica (UCR). One purpose of this collaboration is to expand the neuroscientific and neuropedagogical foundation of Inquiry-Based Science Education, thus providing a perspective that contributes to the dissemination, promotion and consolidation of the IBSE approach. As a first action, in July 2016, the UCR's III Symposium on Neuropedagogy includes as one of its main topics, *"Neuropedagogy and the inquiry-based teaching approach,"* with the participation of National Science Advisors for the I and II MEP Cycles: Dr. Carazo, who serves as the Focal Point in education of the NAC and organizes this symposium at the UCR, and Dr. Quiroga from Bolivia's NAC. This will be used to create links between one of the main universities that train professionals in the field of education, the NAC and the Ministry of Public Education.

This collaboration is expected to generate theoretical and practical inputs to increase the impact IBSE has begun to have on the Costa Rican educational system, by influencing the various levels required for the student to be the direct beneficiary of a mediation that will promote and enhance students' critical, reflective and creative capacity.

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3.9 The Case of Venezuela[12]

In Venezuela, the Academy of Physical, Mathematical and Natural Sciences is responsible for implementing the Inquiry-Based Science Education (IBSE) Program, which we call *Science at School*, in conjunction with the Polar Firms Foundation, a private foundation belonging to Polar Firms.

The Polar Foundation began to participate in 2003 when one of its executives was invited to the II International Conference on Science in Basic Education in Monterrey (Mexico), organized by the Academy of Sciences of Latin America (ACAL), the Public Education Secretariat (SEP) in Mexico, the National Science Research Center (NSRC), the International Council of Scientific Union (ICSU), the InterAcademy Panel (IAP) and other organizations. The goals of the event included sharing experiences and identifying international cooperation strategies to improve science teaching through experiential and Inquiry-based techniques.

These ideas were immediately shared by the Academy of Physical, Mathematical and Natural Sciences, and on August 23, 2004, an agreement was signed between the ACAL, the Academy of Sciences and the Polar Foundation to generate an IBSE program in Venezuela. In October 2004, a team of teachers was chosen to attend the Inter-American Workshop on Strategic Planning for Inquiry-Based Science Education Projects organized by IANAS in Santiago, Chile, from which the basic ideas for the program were drawn. On the basis of the training and experience gained at that event, the first working group was launched to plan an IBSE program in Venezuela, under the leadership of the academic Claudio Bifano, and the technical coordination of a teacher named Diana Hernández.

The first thing we did was to determine the relevance of the experiences of the Properties of Matter Module of the Science and Technology Program for Children of the NSRC (Spanish version of the Chilean IBSE program), regarding the content of the Natural Science and Technology programs of Stage II of basic education in Venezuela.

An analysis of the 19 lessons in the module, based on the contents of the lessons and programs, showed that they corresponded to 5th and 6th grade. Likewise, the results of this analysis made it possible to define the adaptations and modifications required for their use in our schools.

In July 2005, the Academy of Physical, Mathematical and Natural Sciences of Venezuela organized a workshop in Caracas during the III ACAL Conference, at which the IBSE -Venezuela Program was presented to the national and international community. The program launch was attended by Dr. Hernán Chaimovich, Co-Chair of IANAS, ACAL, representatives of the Academy of Physical, Mathematical and Natural Sciences, representatives of the Academies and the IBSE programs of Chile, Brazil, Bolivia, Mexico, Peru, and Colombia, representatives of the Ministry of Science and the Directorates of Education and Technology of Venezuela, as well as a group of Venezuelan teachers and researchers.

Eventually, in April 2006, the IBSE program was launched at five schools in the metropolitan area of Caracas, in neighborhoods in the municipalities of Libertador, Chacao and Sucre, catering to 420 5th grade and 315 6th grade students.

To close this stage of launching the national program, in November 2006, an Inquiry-Based Science Education Workshop on Successes and Missteps was held by the Academy of Physical, Mathematical and Natural Sciences and the Polar Firm Foundation and ACAL and sponsored by IANAS. It was attended by specialists from Venezuela and various Latin American countries focused on improving science teaching through the IBSE program.

12. **Claudio Bifano**, Focal Point Venezuela, Full Member of the Academy of Physical, Mathematical and Natural Sciences, Professor of the Central University of Venezuela; **Diana Hernández Szczurek**, Technical Program Coordinator of Science at School Program; and **Renato Valdivieso,** Science at School.

Objective of the Science at School Program

The program's objectives were defined at the outset and have been maintained over time. Ever since the program was launched, the Academy of Sciences and the Polar Foundation stated that the initiative should remain a *pilot project* that would grow slowly, meeting the demand for it at schools. It should be taught by well-trained teachers, and resources should be available for the development of materials and teacher training and, if possible, it should have the support of the Ministry of Education.

It was never suggested that the program should cover the entire national education system since, in our view, that is the task of government agencies responsible for education. The commitment was to implement the IBSE scheme, and form a group of trained facilitators to replicate the methodology at schools in an academically sound way, prepare educational material and make it available to interested parties, and provide science training workshops for teachers at schools linked to the program.

The final objective agreed on was to lay the foundations for this new methodology in schools that freely wished to implement it without losing sight of the contents of existing education programs. The ultimate aim was to present the results to the Ministry of Education where possible and recommend its implementation nationwide.

Evolution of the program

The program has focused on three main areas: the clearest possible conceptualization for us of the objectives, teachers' professional development and the preparation of educational material.

Creating our own model to apply the inquiry-based technique in sciences

A very important result of all this professional development work was the creation, by teachers, of an inquiry-based model in science in keeping with the context of our schools and the current curricula and teacher training.

In the early years, the program used the inquiry-based methodology with a four-stage learning cycle, as proposed by the National Science Resources Center (NSRC). This stemmed from the fact the program has begun to be used with modules adapted from the NSRC that were being used in Chile.

Subsequently, the training received by teachers from the La main à la pâte (LAMAP) program, made it possible to undertake an analysis from a different perspective based on the ten principles proposed by the program as the basis for guiding inquiry in science. This exercise resulted in the 10 principles of action that guide us:

1. Students observe an object or a phenomenon in the real world and do an experiment with it.
2. In the course of their research, students argue and reason, work in teams, discuss their ideas and results and construct their knowledge. Purely manual activity is not sufficient.
3. The activities proposed to the students by the teacher are organized in sequence through a progression of learning, while leaving students scope for autonomy.
4. A minimum period of two hours per week is devoted to dealing with the same topic for several weeks. The continuity of the activities and the teaching methods followed is consistent with the set of subjects taught at school.
5. Each child is given a notebook of experiences to record his or her observations and conclusions using his or her own words.
6. The main objective is for students to progressively appropriate operational scientific and technical concepts, accompanied by the consolidation of written and oral expression.
7. Families and/or other people from their neighborhood are invited to observe and support the work done in class if they wish.
8. Teachers and researchers from colleges or universities, associated with the program, accompany the work done in class by sharing their expertise with students.
9. Universities linked to the program also place their pedagogical and teaching experience at the service of the teachers' professional service.
10. Teachers can use an *ad hoc* internet site to find the modules to work on, ideas to develop for activities and answers to questions. They

can also participate in cooperative work, by conversing with colleagues, trainers and scientists.

Finally, on the basis of the experience gained after several years of working with the program, together with their participation in the professional development workshops mentioned earlier, the teacher-participants decided to organize their own model of stages in inquiry-based methodology. These steps were structured according to the scheme commonly used by educators in the country to plan instruction, which is based on the activities carried out at three stages of the class: start, development and end (Bifano, Valdivieso and Hernández-Szczurek, 2010).

Professional development

Science classes should be taught by teachers who understand the basic principles of science, are able to stimulate children's curiosity and contribute to developing skills that will clarify questions through the answers children are given through experiments that facilitate teaching.

Accordingly, a program of training workshops for teachers that complements their academic backgrounds has been implemented since 2005.

Since 2008, professional development activities for the IBSE program in Venezuela have received extraordinary support from the corresponding French program LAMAP (La main à la pâte) thanks to the collaboration of the French Embassy in Venezuela and the formal alliance between the Academies of Science of France and Venezuela (in 2009). A propos of this, at the international level (in order to distinguish them from the national workshops mentioned earlier), there have been a series of Teacher Training Workshops (LAMAP) with the participation of French teachers.

Materials

Continuing with the development of Science at School program, ten new modules were added to the initial module. Some, like the Properties of Matter module come from the Science and Technology Program for Children of the National Science Research Center, (which had been translated by the Ministry of Education and the Chilean Academy of Sciences), while others originally come from the French program La main à la pâte (LAMAP).

All these modules were reviewed, corrected and adapted to the local context, by expert teachers in science teaching in conjunction with the Academy of Physical, Mathematical and Natural Sciences and the Polar Firms Foundation.[13]

The topics are related to the contents of the Natural Science and Technology Program of the National Core Curriculum (Venezuela) for elementary education. The possibility has been left open of creating new modules, and more specific topics with less coverage and taking less time to teach. This has been developed through a format called Minimodules, with the possibility of creating additional ones.[14]

The Science at School Series was designed so that each of its modules and mini-modules can be implemented as a curricular package or a supplement to other curricular materials.

Each program module is designed to carry out experiments in the classroom with all the safety measures required by the level at which it is taught, and consists of:

13. The titles of the eleven modules are: We Compare and Measure (First Grade) The Weather (Second grade), Growth and Development of Plants (Third grade), The Route taken by Food in the Digestive System (Third grade), Meet our Friend Water (Third grade) Changes (Fourth grade), Balls, Ramps and Tunnels (fifth grade), Density: a characteristic property of matter (Fifth grade), Mysterious Powders (Sixth Grade), Food and Nutrients (sixth grade), Properties of Matter (sixth grade). The modules were subsequently compiled into a series called *Science at School*.

14. These mini-modules are: Having Fun with Changes of State, How are Edible Oil, Alcohol, Shampoo and Malt Alike?, Combinations that Give the Universe Smell, Color and Flavor: Mixtures.

- A Teacher's Book,
- A Science Notebook for Students, and
- A kit that includes specific material for the module, related to everyday life, which can easily be obtained at supermarkets, bookstores or pharmacies.

All these resources are organized into logistic boxes, assembled at the resource center accompanied by a sheet listing the contents and then sent to the corresponding schools. The logistics box is a sturdy plastic container with a capacity of approximately 70 liters.

The **Teacher's Book** is divided into six teaching lessons and provides guidelines for developing the module in class, such as: general guidelines, location in the curriculum, teaching sequence, list of materials. Each lesson includes a brief introduction, theoretical information for teachers, objectives, materials, duration, class development and expansion activities. It also emphasizes safety rules.

The **science notebook** accompanies the teacher's book and is where students record the work done in class. It is a valuable tool for children to acquire and hone language skills related to written communication.

Teachers may also use the Science for Us book (Polar Firms Foundation, 2009), which offers more simplified teaching sequences, easily handled by inexperienced teachers.

In May 2010, the Jesús Obrero Technical Institute, a school located in a poor neighborhood of Caracas, was established as a pilot center for the Science at School Project and the headquarters of the Resource and Training Center. This space focuses, coordinates and manages the resources required for undertaking the program.

Future plans

Nationwide, the aim of the program is to maintain and perhaps take the program to a larger number of schools by providing training for science teachers. Like the Science at Your School Program in Mexico, we think that the most important thing is to provide teachers who are well trained in different areas of science and broaden the spectrum of professional training.

For this purpose, the Academy has established an agreement with the Andreas Bello Catholic University (UCAB) to teach a Diploma Course in Science Education, like the one offered by the Science at Your School program, which has been studied by several of our facilitators. This syllabus for this diploma course is nearing completion and we hope to be able to offer it by the end of this year.

A non-government organization called Inquiry-Based Science Education: Science at School, attached to the Academy of Physical, Mathematical and Natural Sciences has been created. This NGO which will be responsible for promoting the program, diversifying funding sources and managing the organization and teaching of workshops, the preparation of training materials and providing supplies for the Resource Center.

3.10 The Case of Argentina[15]

The current system defined by the Ministry of Education (ME) for public education includes:

- Pre-elementary or early education: 3-5 year olds
- Elementary school: From the age of 6, covering a total of six years (ages approx. 6-11)
- Middle school: approximately from the age of 12, requiring a total of five years for the standard baccalaureate and six years for technical schools (students graduate as technicians in: electricity, carpentry, mechanics, etc. depending on the specialty chosen)
- Tertiary education includes universities and other tertiary institutes (e.g., teacher training for middle school education in language, mathematics, etc.).

For the elementary and middle school level, the System includes the Natural Science, Technology and Math curricula separately. "Core learning priorities" (CLP) are described for each discipline and cycle. According to its definition, core learning priorities at school refer to a set of central, relevant and significant knowledge, which, incorporated as objects of teaching, help develop, build and expand the cognitive, expressive and social possibilities that children use and recreate on an everyday basis in their encounter with culture, thereby enhancing personal and social experience in a broad sense.

The visit by Professor Pierre Léna in 2004 proved essential to implementing the inquiry-based science model and marked a key milestone for teachers, professors and academics interested in IBSE. Conferences and workshops were held and a cooperation agreement signed for science education, between the French Academy of Sciences, the National Academy of Exact, Physical and Natural Sciences (ANCEFN) and ME. Under this agreement, both Academies and the national ME undertook to actively cooperate in the implementation of Inquiry-Based Science Education (IBSE) in schools and allowed us the free use of resources from the La main à la pâte (LAMAP) program, originally designed by the academics G. Charpak (Nobel Laureate), P. Léna and Y. Quéré. The Spanish translation of one of LAMAP's first publications, a book that appeared in 2006, entitled *Los niños y la ciencia: la aventura de Las manos en la masa:* from the Argentinean series "Ciencia que ladra," Siglo XXI, was authorized.

The second fact that contributed to the development of the Argentinean program was the first Latin American IBSE Workshop in Santiago (Chile), organized by Dr. Jorge Allende in late 2004. It was given in collaboration with the group led by Sally Shuler from the Smithsonian Institute (Washington, USA) and a number of professors at the University of Chile. Argentina was represented by the ANCEFN Focal Point, two representatives of the ME and a middle school teacher. At the meetings with academic representatives, Dr. Allende emphasized the importance of the Academies of Sciences' strong involvement in the implementation of IBSE at schools.

The third influential element was the IAP Workshop on the Evaluation of IBSE Programs 2005-2006, with the participation of key researcher-educators from different parts of the world. This workshop was held in Stockholm (Sweden) from September 21 to 23. Attendees exchanged experiences with the role of contents and procedures in learning, the various evaluation activities, and critical analyses of international assessments (PISA, TIMSS, ROSE, etc), which were extremely valuable for visualizing the various aspects of IBSE. A second workshop was held in Washington. All the material produced, compiled and critically evaluated by a small group led by Wynne Harlem (UK, 2010) was circulated, producing

15. **Norma Nudelman,** Focal Point Argentina, Tenured Professor at the University of Buenos Aires and member of the National Academy of Exact, Physical and Natural Sciences of Argentina.

a first draft of an extremely useful document, which was subsequently discussed at a third Workshop held in Santiago (Chile). The corrected version (Harlem 2012) was translated into Spanish and is an essential tool for the work of IANAS-SEP. In 2006, a group of four teachers appointed by ANCEFN were able to attend the LASER Workshop in Washington, (USA) with the support of OAS-FEMCIDI.

Lastly, a key role was played by the Annual Meetings of IANAS SEP 2004-2014, due to the conviction that these annual meetings are crucial to strengthening all IBSE activities in the region. With the exception of the meeting held in Washington (USA), Argentina participated in all the annual meetings of the program, namely: October 11, 2014, Lima (Peru); September 10, 2013, Santiago (Chile); August 9, 2012, Bogota (Colombia); June 8, 2011, Mexico City; June 7, 2010, Rio de Janeiro (Brazil); July 5, 2008, San José (Costa Rica); July 4, 2007, Mexico City; September 3, 2006, Edmonton (Canada); August 2, 2005, Bogota (Colombia); November 1, 2004, Santiago (Chile).

The IBSE modality began to be implemented at public schools in Argentina in early 2004, as part of the Integral Program for Education Equality (IPEE) organized by the Ministry of Education (ME). It was run by the Natural Sciences Group, consisting of four teachers of Biology, Chemistry, Physics and Astronomy. One workshop was conducted in the Province of Corrientes in 2004 and another in El Chaco in 2005; the workshop structure designed by the ministerial group involved a full week with teachers and comprised several science pedagogy and teaching topics, the development of an experimental module and a dissertation by a "scientific godfather" of ANCEFN. The following year, no IBSE workshops were held, and the original Natural Sciences group from the ME was dissolved. In 2006, in order to continue with IBSE, based on the mandate of the IAP and the experiences of IANAS-SEP, ANCEFN proposed a program called "HaCE (Haciendo Ciencia en la Escuela-Doing Science at School), which is part of its Program to Improve Science and Technology Teaching, sponsored and coordinated by Dr. Norma Sbarbati Nudelman.

Science and technology teaching at elementary schools is a government requirement that dates back several decades. However, teachers complain about students' lack of interest in science and technology issues, while students argue that their classes are "boring" and with little or no relation to their everyday lives. To remedy this situation, IBSE is an innovative form of pedagogy based on research undertaken in the classroom by students, who construct evidence-based knowledge through experimentation. It therefore goes beyond the appropriation of basic science and technology, and develops skills such as: creativity, imagination, critical thinking, oral and written arguments, teamwork and solidarity, highly valued skills in today's workplace. Under the auspices of ME and the Faculty of Sciences at the University of Buenos Aires (UBA), the first HaCE workshop was held on February 22, 2007, with the participation of teachers from six provinces and Buenos Aires (CABA). This is how the first group of 52 "facilitators" who began to replicate the workshops in their respective schools was formed. The 2nd National Workshop was held from June 8-15, 2008 (Vth Week of Science and Technology) with the participation of the National University of Cuyo (Mendoza), Unsur (Bahía Blanca), UNTucumán (Tucumán) and ANCEFN (Buenos Aires).

Since their inception, all the "HaCE" workshops have been provided for public schools, especially those in vulnerable areas. In the first workshop, a number of experimental modules from the "La main à la pâte" (LAMAP) Program were used, thanks to an agreement signed by the French Academy of Sciences, ANCEFN and ME in 2004, authorizing us to use these resources freely. The "HaCE" team then developed original modules based on the fundamental principles of the program and adapted to the CLP of the ME, to provide a useful tool for teachers to implement IBSE and quickly use it in the classroom.

In the "HaCE" Workshops, we taught teachers that the initial step is doubt and asking why things happen, and pointed out that they should encourage *inquiry* about what is observed. From then onwards, in a process of cooperative conceptual construction between teacher and students, children begin to relate to the thinking and knowledge of the natural sciences, within the framework of their social, cultural and temporal context. The point of the "HaCE" workshops is for concepts to be linked to the historical context in which a particular law or theory was developed. Thus, a single activity makes it possible to associate cognitive areas such as biology, physics, chemistry and mathematics with history, language, geography and art, among others. The overall objective of the program is to achieve *an integrated and integrative education*, with relevance to the social context. Its educational foundations are essentially based on the LAMAP philosophy, with certain adaptations to the national school context. Thus, the "HaCE" Program includes the following principles, namely:

1. Students observe an object or a real phenomenon, and experiment with it, working as a team. *They argue, reason, discuss ideas and results, and construct their knowledge* in the same way as a scientist.
2. In order to make them *sustainable*, the modules are designed on the basis of materials that are very economical and easily accessible for any school.
3. To facilitate the teacher's task, the proposed activities are organized in a *learning progression* consistent with the *curriculum designs*.
4. The *weekly class load* and focusing on the same subject for several weeks is adapted to the possibilities of each school.
5. The *quality and continuity of the activities* is ensured, and efforts are made to achieve *education that is integrated* into school subjects as a whole.
6. Students have *science notebooks* (SN), in which to record observations and conclusions in their own words and with their own drawings. The evolution of the SN during the year provides an excellent record of how students' knowledge is progressing.
7. The main objective is the construction and progressive appropriation by pupils of *scientific concepts and operational techniques,* accompanied by the consolidation of *oral and written expression.*
8. *Families and the neighborhood* are invited to become involved in the work done inside and outside the classroom.
9. *ANCEFN members and other scientists (university professors, academics, facilitators)* guarantee the quality of the modules, collaborate in teachers' professional development and accompany work in the classroom.
10. The program includes ongoing collaboration with *educators specialized in science education research* and access to IBSE sites.

To ensure the effective (and rapid) implementation of IBSE in classrooms, the duration of each training workshop for teachers and their workload can easily be adapted to local problems and the general context of the school and/or region. Since the workshops are given to *in-service teachers*, they do not usually take more than one day. The bulk of the workshop is devoted to the experimental development of each module and sharing at the end, when results and concepts are discussed. "Facilitators" do not teach didactics or pedagogy in order to devote most of the time to essential experiences, contents and key concepts, the topics most frequently requested by teachers. In reflecting at the end of the workshop, teachers share their teaching strategies.

Classroom work is done in groups (4-5 students), each of which has a specific role (*leader, secretary, spokesman, person responsible for materials*) decided at random and rotated at the start of each new experience. Roles must be respected, regardless of the preference of each student, which is how they learn to work in teams. They all record their results in the Science Notebook. In the reflecting stage, the spokesperson for each group explains what has been done, which the *secretary* writes on the blackboard. This is the right time to introduce precise *vocabulary*, correct *spelling*, and encourage discussion among the students by presenting the results of all the groups.

The program's activities began at the elementary level, expanding to middle school in 2009 and the technical level in 2011. At the elementary level, workshops were held at the request of the various school districts and/or the MEs: whether municipal, provincial or national. Regional workshops were also held during the school year, with national workshops being held annually in various provinces.

In the "Transition to Middle School Level" workshop, we stress the need to bear in mind the physical, emotional, social and neurological changes at this stage, and the importance of encouraging young students' interest in science and technology. They are constantly exposed to an abundant variety of sources of information, and should be able to examine this flow of all kinds of news with a critical sense and sufficient information, in order to be able to give an opinion and make responsible decisions.

The first workshop for middle school teachers was held in 2009, and for technical school teachers in 2011. Although young people are absolutely fascinated by technological advances that they enjoy on an everyday basis (TV, computers, cell phones, Wi-Fi, Play Station, tablets, etc.) and make great use of them, they do not think that the science teaching they receive at school is connected with issues in their everyday lives; and fewer and fewer school leavers choose to pursue a career in the so-called "hard sciences". Not only students who choose a science-related degree but all high school graduates should be able to understand and apply the basic concepts of science and technology, since they are very important to all activities and their actions as informed citizens. In the design of the modules, we tend to develop new skills: abstract thinking; the confrontation of ideas; global issues, art, biodiversity; *inter-culturalism* and so on.

In the HaCE workshops: teachers and students act as researchers: they observe, experiment, discuss, explain and make proposals as a scientist would in his laboratory. Thus young people approach concepts in the same way as a scientist would, the main objective being to develop various skills linked to the work of science in the student, such as: capacity for the critical observation of a particular empirical fact; capacity for detailed description, both oral and written; ability to obtain data and arrange them in a meaningful way that allows them to analyze, interpret, match results, draw graphs and establish similarities and differences; draw possible conclusions and hypotheses on the basis of evidence in order to predict results in comparable situations; develop a critical spirit, and a capacity for teamwork and the confrontation and discussion of results obtained by others and so on. The teacher accompanies the student in a process whereby inquiry is the first step in the construction of relevant knowledge. Experimental work is suitable for introducing some of the problems of scientific work: observation, measurement, data logging, error weighting, etc. together with the communication and discussion of results. Another aspect to bear in mind when conducting experiments is safety. Students should be taught the precautions that must be taken, creating a responsible attitude towards their safety and that of their classmates.

Argentina is a large country with problems that vary by region. For this reason, for several years, Pilot Centers have been implemented at strategic points in several provinces where "facilitators" trained in the program periodically replicate HaCE workshops in their respective schools and school districts. To this end, the program has the support of graduates from national universities and tertiary colleges and middle school teachers working in the provinces

Other activities sponsored by IANAS in Argentina

At the first meeting of IANAS Focal Points in 2004, they discussed the additional synergy specialists in the various sciences from each country could contribute to science teaching in the region. Thus, Chile was chosen to work on biology, Mexico and Peru on Mathematics, and Argentina on chemistry to collaborate in teacher training in leading edge issues in these disciplines. It was proposed that Argentina should organize workshops on Green Chemistry, which develops environmentally friendly products and processes, a proposal that was enthusiastically greeted by students. In November 2005 in Mendoza, Argentina, the First Theoretical and Practical Latin America Course on Sustainable Chemistry/ Green Chemistry for Middle School Teachers was held, sponsored by IANAS SEP, ANCEFN and the National University of Cuyo (Mendoza). OREALC/ UNESCO paid for the airfares of ten teachers from different ten countries in Latin America who arrived on Sunday. That evening, introductions were made and the first assignments set. The course/workshop was held over a period of five days with experts on each of the topics: fundamental principles of Green Chemistry (GC); alternative energies; toxicity, biotoxicity and persistence; the use of natural products; supercritical fluids (SCF); agrochemicals and pesticides; biodegradable polymers; sustainable organic synthesis, and so on. The course also included laboratory experiments and visits to two chemical plants where participants could observe the application of the rules of GC *in situ*.

Other Latin American workshops on GC were held in Bahia Blanca (2006), Corrientes (2007), Buenos Aires (2010), Santa Fe (2014) and Buenos Aires (2015). The last year they were sponsored by IANAS was 2007, after which workshops were limited to 3 days. Unfortunately, no further funds were obtained to pay for international airfares although some Latin American teachers were able to obtain support from their institutions. In 2015, eleven Uruguayan teachers were able to participate. Interestingly, taking advantage of this *expertise*, a number of Focal Points in neighboring countries asked us to organize workshops on *Sustainable Chemistry/Green Chemistry for middle school teachers* at various locations in Brazil, Bolivia, Chile and Uruguay. This format benefitted more teachers in the host country than those who would have been able to be trained by traveling to Argentina.

Two other Latin American events on Science Education were held in Buenos Aires, Argentina. The Symposium on Strategic Planning for Science Education, sponsored by IANAS SEP was held in November 2011. During the previous semester we had worked productively via e-mail, doing the SWAT Analysis we jointly completed in the first days. Over the next two days, the IANAS SEP Strategic Plan was drawn up for the next three years. Five areas of interest were organized, with coordinators being appointed for each one, together with Focal Points. This Strategic Planning 2012-2014 was submitted to IANAS for consideration and updated each year.

The other significant event was the Regional Focus Symposium on Inquiry-Based Science, Technology, Engineering and Mathematics Education, jointly organized by ANCEFN and RELAB held on November 13, 2014, within the framework of the Ibero-American Congress on Science, Technology , Innovation and Education, held by the Organization of American States (OAS). The symposium sought to show the commitment of the scientific community in the region to improving the quality of education in STEM, contributing to the "scientific culture" by promoting convergence with educators, communicators and society in general, and strengthening the integration of the Latin American scientific and educational community. The sponsorship of MINCYT, OEI, IANAS and UNESCO permitted the participation of scientists and educators from 23 countries who, at the end of the symposium, issued a statement of their commitment to IBSE/STEM.

Argentina is a large country with problems that vary by region. For this reason, for several years, Pilot Centers have been implemented at strategic points in several provinces where "facilitators" trained in the program periodically replicate HaCE workshops at their respective schools and school districts. To do this, the program has the support of graduates from national universities and other tertiary institutions, as well as secondary teachers working in the provinces.

It should be noted that the program does not have financial support. All the work has been done *ad-honorem* and it is only fair to mention the main collaborators since its inception: Susana Palomino, Laura Melchiorre, Fabián Blanco, Clara Cabrera, María C. Condorelli, Marta Puiggioni, Laura Tarante, Paola González, Julieta Valdez, who have devoted their efforts and personal time to undertaking the workshop program, in addition to all the other teachers who were gradually incorporated.

Since March 2016, ANCEFN has promoted the involvement of other National Academies related to STEM. After several meetings with the Academies of Education, Engineering and Science as well as Agronomy and Veterinary Medicine in Córdoba and Buenos Aires, the good news is that an InterAcademy Committee of seven National Academies has been formed to promote IBSE/STEM at the three educational levels. We hope that by 2017, a new stage will begin for the program where the multiplication of efforts, with the support of the Ministry of Education and Sports and the Ministry of Science, Technology and Innovation, could result in IBSE being implemented at schools throughout the country.

3.11 The Case of Peru[16]

The Inquiry-Based Science Education Program (IBSE) for children in Regular Basic Education was begun in Peru by the National Academy of Sciences in 2004, under the auspices of the Inter-American Network of Academies of Sciences (IANAS), comprising the Academies of Sciences of Canada, the United States and Mexico, Cuba, Dominican Republic, Guatemala, Costa Rica and Nicaragua; Argentina, Bolivia, Brazil, Colombia, Chile, Ecuador, Peru and Venezuela.

IBSE methodology is based on new knowledge about the learning process drawn from research and seeks to bring the skills and attitudes associated with scientific work to the classroom. Using the inquiry method, children explore the natural world, which leads them to ask questions, find explanations, test them and communicate their ideas to others. The process is guided by their own curiosity in their attempts to understand the phenomena of their environment.

16. **César Carranza,** Focal Point Peru, Member of the Academy of Sciences of Peru, Professor Emeritus at the Pontifical Catholic University, and **María Elena González Romero**, professor at the University of San Marcos.

The aim of the IBSE program is to use inquiry to create the ability to explain the world around them using scientific procedures as a tool for living and learning on their own.

Once it realized the importance of this program, the National Academy of Sciences of Peru (ANC-PERU) decided to adopt it in 2004, for which it appointed Dr. César Carranza, who negotiated a collaboration agreement with the Pontifical Catholic University of Peru (PUCP), of which he is emeritus professor, prioritizing the selection of young university professors: mathematicians, biologists, physicists and chemists (with doctorates or master's degrees) interested in secondary and elementary teaching in order to train them in IBSE methodology in the Latin American countries that had already adopted IBSE methodology before 2004.

In December 2004, the IBSE-PERU Group was formed in the PUCP, led by Dr. César Carranza and comprising young professionals in the areas of mathematics (MSc. Rosa Cardoso, MSc. Alex Molina and MSc. Mariano González), biology (Ph.D. María Elena González and Msc. Ruth Zelada), physics (MSc. Hugo Medina and MSc. Hernán Montes), chemistry (Dr. Maynard Kong and MSc. Vadillo), who were trained in IBSE methodology in Chile, Colombia, Venezuela, Brazil and Bolivia, and then shared the knowledge they had acquired by conducting seminars, courses and meetings both nationally and internationally. These activities have made it possible to train teachers in the inquiry method in elementary and secondary education at the national level. One of the goals achieved by the group has been to train clusters at various education centers nationwide.

Clusters are working groups made up of one teacher in the area of math, one in biology, one in physics and one in chemistry trained in IBSE methodology by the IBSE-Peru Group or other Latin American IBSE groups. There are two types of cluster:

a. University Cluster: Responsible for organizing workshops, inter-American and national courses, and designing activity modules and
b. Secondary Cluster: Responsible for teaching modules to elementary teachers and personally showing them how to develop their model classes. Both clusters are in constant contact with the university IBSE-PUCP cluster. Close links are established between the university and secondary clusters in the same region, so that the former permanently advise the latter on scientific and methodological aspects. In the event that there are no secondary clusters in a region, advice is provided directly from Lima by the university IBSE-PUCP Cluster. The working method involves bringing together university clusters and determining the topics that can be taught to children in the six grades of elementary school and the five grades of secondary school, following the order in which they appear in the official Ministry of Education (MINEDU) curriculum. Once the topics have been chosen, modules published in other countries and suggested and then adapted to the Peruvian context. If there are no modules published on the topic, the IBSE-Peru group, together with the university and secondary clusters, design and write new modules. A one-week course (40 hours) is given, attended by members of the Clusters of elementary and secondary school teachers, chosen because of their ability and commitment to implementing the modules in their respective classrooms. The course includes the presentation of the IBSE-Peru project modules in each of the basic science areas, with particular emphasis on the methodology and the meaning of the scientific concepts involved in them, the explanation of the basic guidelines for the inquiry method and therefore IBSE methodology and lastly, the statement of objectives, work undertaken and goals achieved by the IBSE-Peru Group and the national clusters by Dr. César Carranza.

In 2006, several Inter-American Courses were organized, developed by the IBSE-Peru Group for training elementary and secondary school teachers in Peru and other countries.

Support received from IANAS and other sources of support

IANAS has sponsored the activities of the IBSE-Peru Group mainly through ANC-Peru. We have also received regular support from the Pontifical Catholic University of Peru (PUCP), based on the signing of an agreement between the ACN and this university, which has enabled its scientists to participate in the IBSE-Peru project during their working hours. PUCP's contribution includes permitting the use of its classrooms, auditoriums and computer centers in the workshops, seminars and classes taught by the IBSE-Peru group by school teachers and professionals from other national universities.

The Peruvian Ministry of Education provides financial support for the National Academy of Sciences, which consists of an annual donation of $32,284.10 USD (S/.100 000 new soles) of which $7,766 USD (S/.25 725 new soles) are assigned to the IBSE-Peru project.

Production of original materials

The IBSE-Peru group has provided constant bibliographical support for the scientific activities designed by our research scientists, which is expected to be published in the form of an activity book this year. A common feature of these activities is the use of mathematics in biological, chemical and/or physical issues, as well as the use of IBSE design methodology.

The work of IBSE scientists in the classroom has resulted in the publication of research papers and presentations at national and international conferences. This is the case of the "Inquiry-based Methodology for Schoolchildren's Scientific Education," presented at the Symposium on Science and Technology for Everyone in the 21st Century developed in Lima in 2006, whose lead author is Dr. Maynard Kong Moreno, a member of IBSE-Peru group in the area of chemistry. This article discusses the challenge of teaching students science and fostering inquiry in them. It also explains IBSE methodology and the first IBSE activities in our country. It ends with the need for a strategic plan for its mass implementation in Peru.

MSc. Rosa Cardoso, Ph.D. María Elena González and Msc. Alex Molina presented the article entitled "Inquiry in Math Classes" (IBSE) – Peru"- National Academy of Sciences Peru (ANC). The article is the result of observations made during the IBSE workshops and sessions and describes the process followed by the inquiry method in a class where biology and mathematics topics are linked.

Peruvian scientists renowned for their research both nationally and internationally have been invited to publish on issues involving Peruvian Megadiversity and the research conducted on this. Thus, Agronomic Engineer Alberto Salas, a renowned Peruvian researcher with over 50 years of experience in the study and identification of the immense genetic diversity of Peruvian native potatoes, published a book on "Andean Diversity: *The potato and its wild relatives, a source of food for humanity* (Salas et. Al., 2014). Publication of the book was sponsored by the PUCP, the International Potato Center and the ANC of Peru. It describes the history, distribution and genetic diversity of cultivated potatoes and the wild varieties found in Peruvian territory, and their nutritional value and anti-cancer properties.

Dr. Gustavo F. Gonzales, Director of the Research Circle on Plants with Effects on Health of the Cayetano Heredia Peruvian University and a researcher of the properties of the Maca in reproduction was invited to write the book "*Maca: The Miracle of the Andes*" published in 2014 under the auspices of the National Academy of Sciences and the PUCP.

As part of the Second Inter-American Science Course for Elementary School Teacher Trainers, held from February 16 to 20, 2009 in Lima, *Tópicos de Matemáticas para formadores de Profesores de Educación Primaria* and *Tópicos de Geometría para Formadores de Profesores de Educación Primaria* (Carranza et. al., 2009) were published. The authors, who are also members of IBSE Group-Peru are Dr. César Carranza, MSc. Rosa Cardoso Paredes, MSc. Alex Molina Sotomayor and Dr. Hernán Neciosup Puican. This publication was sponsored by the OAS, IANAS and the Ministry of Education of Peru.

MSc. Ruth Zelada (Biology) has designed the book entitled "Quinoa" which is currently in press. Lastly, this year, with a grant from the Ministry of Education to the ANC, the book entitled "Algebra" by César Carranza, will be reprinted. This text has been used by several generations at the university level for the training of mathematicians and secondary school teachers specializing in math.

Impact of IBSE in the country

The main impact of the use of the inquiry method and therefore IBSE in Peru can be seen in the improvement of secondary school education at the basic science level: chemistry, physics, biology and mathematics, which have been relegated by the various educational programs proposed by the Peruvian government in recent years. The IBSE activities proposed not only help integrate the different areas of science, but also elicit interest in scientific research in both children and adults and promote skills development, in basic sciences and communication. They also focus on the need to improve reading comprehension in children and teachers alike.

At the same time, they significantly develop the creativity of children and adolescents, typical of their age, which is positively channeled by the scientific activities carried out in class. This gives rise to new questions and group projects, which in turn contribute to students' scientific development.

We currently have 895 professionals, including teachers and scientists nationwide who are able to teach IBSE methodology to other educational professionals and maintain the multiplying process in their respective regions. A clear example is the formation of six university clusters and 21 secondary school education clusters. This in turn allowed us to establish pilot programs for training elementary school teachers, through clusters of secondary school teachers trained at state schools with elementary and secondary school sections. They identified elementary teachers from the same school with the commitment and ability to participate in the project. Once the elementary teachers had been chosen, they developed modules with the children, under the supervision of the cluster of secondary school teachers, thus maintaining the multiplier process of IBSE methodology.

3.12 The case of Nicaragua[17]

Since its founding in 2009, the Academy of Sciences of Nicaragua (ANC) has promoted various international initiatives such as Inquiry-Based Science Education (IBSE) in Nicaragua, in collaboration with organizations such as the Global Network of Academies of Sciences, the Inter-American Network of Academies of Sciences (IANAS) and very particularly, with experts from the Mexican Academy of Sciences, and the Academies of Venezuela and Costa Rica. Hence, the ANC has been promoting science among teachers in the development of research methodology through the IBSE program. This is one of the instruments which, in the set of processes and educational activities, the ACN offers science teachers in order to update and expand their knowledge, improve their training and educational development, thereby contributing to the academic process of academic modernization and the improvement of science education in Nicaragua.

In short, through the IBSE program, efforts are being made to train teachers in this new methodology and develop students' ability to explain the world around them, using scientific procedures as a tool for life and for learning on their own.

Training is provided through intensive workshops lasting an average of two days, given by members of the Academy of Sciences of Nicaragua, with the support of teachers from other countries. Hundreds of teachers from various schools throughout the country have participated in the workshops. This collaboration and interest in the development of the IBSE program reflects the scientific community's commitment to the education of the majority and to teachers as key actors in this process.

The methodology of the IBSE program undertaken in the workshops is due to the importance of ensuring that teachers and other actors involved in the program learn in the same way they are expected to teach their pupils. In other

17. Professor **Jorge A. Huete-Pérez,** Vice President of the Academy of Sciences of Nicaragua and General Vice Chancellor of the Central American University (UCA).

words, teachers and scientists are trained in inquiry-based methodology by practicing inquiry.

Regarding organizational aspects, workshops have usually been given in groups of no more than 25 teachers in order to optimize the human and material resources in the workshop. Courses are usually given on consecutive days, and include two stages: Initially, a general framework is provided of what research methodology is and the need to use it to teach science is explained. At the second stage, we proceed to the development of practical workshops in which teachers assume the role of students.

The ACN's first contact with IBSE methodology took place in 2011, when a major effort was made to ensure the participation of collaborators in meetings at which the research methodology was explained. The first member of the NAC to participate was Dr. Rafael Lucio in the Latin American Seminar, organized by the Academy of Sciences of Venezuela, with support from the French Embassy, when various countries presented their progress in the implementation of the Science Teaching Model. This event was promoted by Academies of Sciences from all over the world, and supported by the Ministry of Education of France and French embassies in the area.

That same year, on the invitation of the Mexican Academy of Sciences, delegates from the NAC participated in the Inquiry-Based Science Teaching Camp, held in August 2011. The experience allowed our delegates to have their first contact with inquiry methodology and to familiarize themselves with the experiential dynamic characteristic of Inquiry-Based Methodology.

These same delegates subsequently participated (November 2011) in the "Science Education" Congress held in Mexico; while the director of Fe y Alegría was incorporated into the team. This Congress enabled participants to see the scope and depth of the methodology achieved in nearby contexts.

The first training workshop on Inquiry-Based Science Teaching in Nicaragua was held on December 12 and 13, 2012. The venue was the Central American University (UCA), and included the full participation of 43 workshop participants divided into two groups: one with trainers (13) and another with elementary school teachers (30). The workshop was supported by the Mexican Academy of Sciences.

The first online diploma course on inquiry methodology began on February 3, 2012, and was given by the Mexican Academy of Sciences. During this first stage, the participation of eight Nicaraguan teachers was secured, of which only four managed to complete the diploma course satisfactorily. Among the causes of failure, we identified the lack of follow-up given by the NAC to participants in the diploma course.

The Second Workshop was held on November 29 and 30, 2012, with the participation of 160 teachers and the support of the Mexican Academy of Sciences. The participation of two national teachers, Liana Yuri and Pedro Menocal, who took the diploma course online, was also secured. They contributed with their respective workshops on "Separating Mixtures" and "Changes of State." The largest project that has so far been involved in the NAC was developed in 2014. It is the IBSE Project, Bluefields edition (South Caribbean Coast Autonomous Region). It was supported by UNICEF and undertaken in coordination with the Ministry of Education of the Autonomous Regional Education System (SEAR). The following table shows some of the key activities of this project.

Parallel to the development of the Bluefields IBSE program, in March 2015, a list of 15 participants was drawn up for the online diploma course on inquiry methodology, taught by the Mexican Academy of Sciences. This was the second edition in which Nicaragua participated. However, none of the participants satisfactorily completed the diploma course. The causes of failure to complete the diploma course included the lack of follow-up for the participants and the fact that teachers saw no immediate need to participate in it.

A workshop to be taught in Nicaragua by two French academics who are experts on inquiry methodology, scheduled to be held in October 2015 was frustrated mainly by difficulties in obtaining the participation of the Ministry of Education of Nicaragua, which, citing reasons of internal

Main activities of the IBSE Project, Bluefields edition

Year	Month	Day	Activity
2014	November	12,13 and 14	Facilitators' Workshop
	December	11	Follow-up meeting
2015	January	15	Homework Assignment Meeting
	February	6	Preparatory visit for reproduction workshop
	February	24, 25 and 26	Reproduction workshop (with teachers from 3rd to 6th grade)
	March	13	Preparatory Meeting
	March	20	Review instrument standardization visit
	April	10	Follow-up process review meeting
	April	24	Visit for the three meetings. Unicef and SEAR, directors (in the Evaluation, Planning and Educational Training Workshop (TEPCE)) and facilitators (in the municipal delegation)
	May	9	Preparatory meeting for evaluation
	May	25 and 26	Evaluation Workshop
	June	15	Laguna de Perlas Evaluation Workshop

logistics, refused to authorize public school teachers to participate in the workshop. Consequently, the French cooperation department, in charge of the visit, declined to sponsor the academics' visit to Nicaragua.

This setback in the implementation of this workshop in Nicaragua prompted the ACN to send two of our IBSE collaborators to participate in the workshop held in neighboring Costa Rica for one week (from October 26 to 30, 2015).

The first lesson learned from the country's experience with the IBSE program is that, despite the difficulties, it is possible to at least partly advance the implementation of this international program in Nicaragua. As can be seen from this brief tour, the NAS's perseverance has made it possible to obtain some core funding. Valuable international relations have been established particularly with Mexico, Venezuela and France, and a certain amount of funding has been secured, which the National Assembly of Nicaragua approved for the Academy.

However, another major lesson learned over the years is that the implementation of IBSE in Nicaragua cannot move as quickly or widely as it could without the support of its Ministry of Education. So far it has not been possible to obtain this support, despite the insistence of the NAS and other actors to involve it in the program. The largest experience of IBSE was its Bluefields version, coordinated by the Ministry of Education of the Autonomous Regional Government of the Southern Caribbean Coast based in Bluefields.

Another lesson learned, based on the failure of the virtual diploma courses coordinated with the Mexican Academy of Sciences, is that a program such as the IBSE requires constant, ongoing, sustained monitoring to overcome the obstacles and difficulties encountered in implementing an educational innovation. In cases such as that of Nicaragua, this is hampered by the lack of a basic budget for this type of monitoring.

3.13 The Case of Guatemala[18]

After considerable effort, the Sciences at School Program was eventually implemented in Guatemala in 2009 at the initiative of Dr. María del Carmen Samayoa. It is designed to implement the science education program at the country's schools using Inquiry-Based Science Education (IBSE) methodology. This program has been supported by the Science at Your School program coordinated by the Mexican Academy of Sciences, and it has signed an agreement with the Ministry of Education, the National Science and Technology Secretariat and the Guatemalan Academy of Physical and Natural Sciences.

Twelve years of education has been compulsory in Guatemala since 2012. It consists of one year of preschool, six years of elementary school and five years of middle and high school before going to university.

Our national science and mathematics curriculum ranges from the preschool level to the last year of high school and, yet, science programs for years seven to nine are a mixture of several different things ranging from the study of earth to physics, and end with life sciences. It is assumed that IBSE is included in the techniques used by teachers in the classroom and in all the other subjects on the national curriculum, although teachers still lack training in the use of inquiry-based education in class.

In November 2008, a cooperation agreement was signed between the Ministry of Education, the National Secretariat of Science and Technology and the Academy of Medical, Physical and Natural Sciences of Guatemala to launch the program "Science at School" program. A number of extensions were signed to continue implementing the program until 2016. We are now in the process of signing a four-year extension (until 2020).

18. **Maria del Carmen Samayoa,** Guatemala Focal Point, President of the Academy of Medical, Physical and Natural Sciences of Guatemala.

The main purpose of the project called "Science at School" is cooperation with the Ministry of Education in training teachers in IBSE. The one-year program consists of eight modules, whose contents are adapted to the National Curriculum.

Each of the three parts is responsible for different topics. The Ministry of Education mainly selects schools where the program will be implemented. The National Secretariat of Science and Technology (SENACYT) co-finances the project and is responsible for materials production. The Academy coordinates international support and delivers the materials required for the implementation of the project using the methodology mentioned to the Ministry of Education.

Every year, 60 teachers from the same number of schools are incorporated into the project and the educational materials needed to implement the National Curriculum in the area of natural sciences and technology are provided, reviewed and validated.

The program's objectives including helping the Ministry of Education incorporate technology into science teaching through the use of IBSE methodology in the curriculum. We must give teachers a flexible program reflecting current educational trends.

We began with the first group of 20 teachers who implemented the Mexican Science at Your School Program. When we worked on this, we became aware of our teachers' lack of knowledge in the field of science, which led us to spend one hour of our workshop specifically on teaching the subject of science, while the rest of the other hour was used to help them understand the IBSE system. Meetings were held twice a month with volunteer facilitators. We attempted to determine the extent of their knowledge before the start of each session in order to give the classes as effectively as possible. After the training, the program coordinator visited the various institutions to evaluate and reevaluate teachers regarding the implementation of the methodology. At the end of the year, we conducted a closing workshop in which students used all the techniques they had learned.

The way the modules are evaluated has changed. Initially, we only had one after 10 months of work; in the second year, we introduced a diagnostic test and a final evaluation; in the third year we had an evaluation at the end of each module and, now, an assessment is carried out at the end of each class. Teachers' level of knowledge has improved as a result of this system. No monitoring has been carried out since it was decided that this should be the responsibility of the Ministry of Education, which has so far failed to do so.

Guatemala has participated in several workshops in Mexico, Peru, Canada, Brazil, the United Kingdom and Venezuela.

The OAS/FEMCIDI program provided support for the first two years of the program, enabling experts from countries such as Chile, Colombia and Mexico to give various workshops. Thereafter, all the experts who came to Guatemala were received by its own Academy (especially the Mexican Academy of Sciences) or by the program itself.

The World Network of Academies of Sciences and IANAS are responsible for implementing the central idea at annual meetings. We also have the support of a private company in Guatemala and UNESCO. We must expand our roster of sponsors and continue the program because Guatemala has decided to voluntarily participate in the IANAS program by making extraordinary efforts to keep teachers informed and trained in IBSE methodology.

We intend to continue holding workshops at the end of each year and to secure the participation of all teachers who have earned their diplomas in recent years with the help of Mexican experts. **What we have achieved to date serves as an incentive to advance for the benefit of Guatemalan children.**

We would like the National University of Guatemala to endorse the "Science at School" certificate as part of its Continuous Education program, which would give participants added value.

3.14 The Case of Bolivia[19]

Brief history

Bolivia's participation in the Inquiry-Based Science Education Program (IBSE) began with an invitation to the President of the National Academy of Sciences of Bolivia (ANCB) to participate in the Strategic Planning Workshop in Santiago in November 2004, which was attended by the President of the Bolivian Organization of Women in Science (OBMC) on his behalf. On her return, the delegate informed the president of the Academy of the developments in the workshop and the IBSE program, and its origin and development in certain countries. On the basis of this information, a working agenda for 2005 was drawn up.

Earlier that year, the president of the OBMC shared information and materials from the strategic planning workshop with scientific researchers from the OBMC, who had expressed their interest in actively participating in the program. At the end of the first semester, the Bolivia IBSE team was organized and the president of the OBMC was designated as IBSE Program Coordinator and IANAS

19. **Elsa Quiroga,** Bolivia Focal Point, President of the Bolivian Organization of Women in Science, National Academy of Sciences of Bolivia.

SEP Focal Point. The OBMC has chapters in five cities in the country, which bodes well for the future expansion of the program.

The main activity proposed is the study and analysis of the program. The coordinator's participation in Focal Point meetings contributes to this goal, because of the possibility of expanding key aspects of the program and the opportunity to access certain science modules and experimental material for elementary school teaching.

In 2006, the IBSE-Bolivia team advanced to a second stage in which it emphasized the review, analysis and discussion of the methodology and modules. An action plan was drawn up to be undertaken in two stages:

First Moment: The modules were validated with groups of children at two urban schools; both teachers and children showed great motivation and interest in the inquiry activities.

As a result of this positive experience, meetings were scheduled for the review, analysis, interpretation and possible adaptation of the material (science modules) to the context and school curriculum, for which interdisciplinary groups were organized by module.

Second moment: Other professionals and researchers in physical and chemical sciences, biology and the environment were invited to form part of the interdisciplinary groups. The presentation of the results of the studies of each group was scheduled for the OBMC plenary session.

At both moments, the science education researchers were on hand to provide support and teaching guidance. The action plan was approved by the ANCB President.

Once the action plan had been developed, and on the basis of the program material and new contributions by the groups, the Inquiry-Based Science Education Program project was drawn up and submitted to the President of the National Academy of Sciences, who approved it and pledged to provide the necessary administrative and scientific support. The IBSE program was formalized in Bolivia under the name of "Science Goes to School". In October, the president of the academy and the program coordinator presented the project to the MEC authorities, and were subsequently invited to provide a demonstration of the methodology.

In November, a new strategic planning workshop was organized in Santiago, attended by two science researchers, a science educator and the National Director of Elementary Education of the Chilean Ministry of Education (MEC).

Commitment of IBSE Team-Bolivia

Since the inception of the Bolivian Organization of Women in Science (OBMC), its researchers and visiting researchers have identified with the program, developing their commitment to it and their capacity for teamwork. They have enthusiastically and responsibly assumed the commitment to:

a. Provide children experiences that encourage them to learn science and enhance their skills.
b. Help teachers facilitate learning and improve their science teaching strategies.
c. Develop motivating actions that will promote the formation of learning communities.
d. Involve researchers(s) in scientific areas to facilitate the transfer of scientific methods and processes.
e. Create a learning environment to enable students, teachers and researcher(s) to interact in science classes.

Activities undertaken in specific areas of the IBSE Program

Stage I:

The period from 2007 to 2009 involved a great deal of training, dissemination of the program and materials production, with the support of IANAS and local sponsorship from the Vice-President's Office of Scientific and Technical Research (VICYT) and the Bolivian National Academy of Science (ANCB). From the outset, the IBSE team focused on two key areas of program development: professional development and materials development.

A. Professional development:
To provide scientific support for the area, the organization of Inquiry-Based Science Education was proposed, whose objectives are:

- A.1 Formation of a team of scientific monitors for the IBSE Program.
- A.2 Training of guide teachers for teachers.
- A.3 Training in inquiry-based methodology for elementary level science teachers.

To achieve these goals, five Latin American workshops were held, two in 2006 (one per semester), two in 2007 (also one per semester) and one during the first half of 2009; with the participation of foreign and national facilitators from the IBSE projects in Brazil, Colombia, Chile, Ecuador, Peru, Venezuela and Bolivia, as well as teachers from these countries. All the workshops were conducted in ANCB settings.

Result of the five Latin American workshops:
Achievement of objectives A.1 and A.2

» A.1 Training of 50 scientific instructors, 34 national and 16 foreign. The national science instructors who were trained are all science researchers in different cities and chapters of OBMC; the other monitors are guest researchers.
» A.2 Train 25 guide teachers (20 national and 5 foreign).

During the same period, local workshops were planned to achieve objective A.3. To this end, approximately 30 training workshops were given on inquiry-based methodology for elementary and secondary school teachers in various regions and cities, where the OBMC has chapters, meaning that researchers participating in the program act as the facilitators of the workshops.

Result of local workshops:
Achievement of objective A.3:

» Gradual appropriation of methodology by teachers.
» Motivation to produce learning guides.
» Need to reinforce adaptation of inquiry experiences by course and level.

In 2008 and 2009, under the auspices of IANAS, activities were organized in certain countries such as internships in pilot schools, camps, courses and workshops on chemistry and biology, in which the team monitors participated according to their specialty areas.

B. Materials development:
In this sphere, the team of monitors proposed adapting some of the guides for the science modules at the elementary level as well as the contents of some of the modules to the local context. During the second phase, they proposed developing:

- B.1 Teaching guides for natural science and mathematics topics in the syllabus for teachers to use.
- B.2 Scientific information readings corresponding to the teaching topics.
- B.3 Learning Guides topics related to natural sciences and mathematics for children. The set of learning guides corresponding to a module comprise the respective science and mathematics notebooks.

Stage II:

The activities carried out from 2010 to 2012 maintain continuity as regards teacher training and the production of materials corresponding to the areas of professional development and materials development; outreach activities were also conducted.

A. Professional development
In 2010 and 2011, new courses in chemistry, biology and science conferences were organized, in which the team monitors participated, together with the teacher guides; contacts between Focal Points facilitated this participation.

All the participants in these activities were committed to sharing new information and new learning at internal workshops for the IBSE team and at local training workshops in natural and mathematical sciences with an inquiry-based approach.

Workshops to practice inquiry-based methodology continued with new groups of teachers and new institutions, including the La Salle University, science teachers' associations and private schools' associations.

With all the experience and knowledge gained by the team of monitors in the IBSE program as active participants in various activities since 2006, it has been proposed to develop a post-graduate Project for training guide teachers in the use of inquiry-based methodology at the elementary level. For this purpose, and with the support of the ANCB and OBMC, in early 2010, it was agreed with La Salle University to develop post-degree courses in the second half of the year and in 2011. Monitors in the IBSE team meet in interdisciplinary groups to work on the production of new modules for the new project.

Results of post-degree courses in 2010 and 2011:

» 40 guide teachers trained with the ability to:
  - Teach natural sciences and mathematics based on inquiry.
  - Adapt inquiry experiences to various elementary school grades.
  - Develop their own inquiry guides
  - Accompany elementary school teachers in the classroom and form work teams.

At the beginning of the 2012 school year, some of the teachers asked the IBSE team to visit their schools to make observations in the classroom and support them in the implementation of the methodology in science classes. This created the opportunity to make in situ observations, make the appropriate reinforcements also in situ, and support and work together with teachers in planning the Inquiry activities. For their part, the guide teachers have the opportunity to practice how to do classroom observation and how to accompany teachers at their schools.

Science at Your School Program:

In 2012, master teachers and monitors in the program participated in the virtual diploma course Science at your School for the elementary level. The program is promoted and organized by the Mexican Academy of Sciences. The agreement between our academies facilitated this participation and a group of ten teachers received certificates for the diploma course. This situation encouraged other monitors and teachers to participate in new diploma courses.

B. Materials development

In support of the post-degree courses project scheduled for 2010 and 2011, for the first stage of the guide teacher training, and in view of curricular needs, a number of elementary level science modules were adapted, such as those corresponding to chemistry, physics and sciences.

During the second phase, in keeping with the needs of the context, interdisciplinary groups developed new modules, among which the Theory of Inquiry, Bio-Science, Evolution, Mathematics, and Health and Nutrition.

In a third stage, in response to teachers' and master teachers' interest in obtaining access to more information at both the theoretical and experimental level, we set out to develop a "Guide to experiments in Natural Sciences and Mathematics at the elementary level," which we published using our own resources at the end of 2011 with a total of 500 copies.

C. Program Outreach

This involved the presentation of the program and the dissemination of all printed materials (modules, texts, guides), CDs, visuo-tactile and digital materials in different areas and at various educational events.

The first stage: 2009 and 2010

- The ANCB, OBMC and IBSE Project were invited by the Organization of American States (OAS) to participate in the Day of the Americas Fair on April 14, 2009.
- The IBSE Project was invited to participate in the First Projects and Educational Initiatives

Fair, organized by the Ministry of Education on July 30 and 31, 2010. In August, the program coordinator was invited to a demonstration of the inquiry methodology to elementary and secondary curriculum technicians of the MEC.
- The IBSE project was invited to participate in the Educational Projects Fairs organized by the Municipality of La Paz, in 2010 and 2011.

Second Stage: 2011 and 2012
- With the sponsorship and the support of VICYT, ANCB and OBMC, the First National Meeting of Teachers and Students of the "Science Goes to School" Program was held in the city of Cochabamba on November 25 and 26, 2011. Proceedings of the topics presented at the meeting are available.
- With the sponsorship and support of ANCB and OBMC, inquiry workshops have continued, including assessment on the inquiry approach for elementary and secondary school teachers.
- In 2012, holiday math and science courses for children from 4th to 6th grades of elementary school were held at the ANCB facilities.
- The same year, with the support of the OBMC and the IBSE Team, the Science Club for children was founded, and scientific excursions organized. A group of monitors is responsible for this new project.

Third Stage: 2013-2015 (outreach, research and production)
- Training activities for teachers at schools and colleges who requested workshops on inquiry-based learning and evaluation were maintained.
- On the basis of the new educational model that promotes socio-community and productive education, the productive dimension was reinforced in the learning guides.
- The new training experiences, the continuous analysis and reflection on the scientific and didactic structure of the inquiry cycle and the evidence of learning prompted the team to reformulate the stages of the inquiry cycle.
- In the process of studying the phases of the cycle, the main focus was on the importance of developing thought processes and the evidence of these processes and the relationship between the phases and the teaching strategies characteristic of each one with the capacity to activate or trigger mental processes.

The impact of the IBSE Programs

Translated into the results of the two areas of action of the program, professional development and materials development, evinced through classroom observation, interviews, productions (guides and modules), increased abilities and skills, the development of an attitude of openness towards research, the following was achieved by each group actively participating in the program:

In the monitors:
- Adaptation of model guides and production of new guides (modules)
- Implementation of training strategies
- Teamwork and commitment to the program (voluntary)
- Entrepreneurship
- Productive capacity
- Monitoring and classroom support

In the teachers and guide teachers:
- Level of ownership of the methodology and its application in the classroom
- Adaptation of the guides to the classroom context. Transfer to other areas
- Development of new inquiry guidelines for issues on the school curriculum
- Ability to socialize one's own experiences
- Monitoring and classroom support

In students:
- Increased skills and development of scientific attitudes
- Independence in classroom work. Language development
- Proposing alternative solutions to problems
- Formulation of new predictions. Checking expectations
- Teamwork and good performance of roles

It is important to highlight some of the skills and attitudes of the children and teachers who used the inquiry-based approach for an average of three consecutive years:

Skills:

- Observe the whole and the parts
- Record and organize information
- Predict what might happen
- Discover what is new
- Check predictions, propose new strategies
- Make decisions
- Make designs, draw the phenomenon or situation, handle the equipment
- Form new mental images, solve problems
- Represent acquired knowledge (maps, diagrams)
- Do summaries, increase their vocabulary, and speaking and writing

Attitudes:

- Be observant, experience curiosity
- Be independent, work in a team
- Be ready for the activity, make commitments
- Find information, share, enjoy what you do

Program development strategies

a) Favorable

- Sponsorship and ongoing support of the president of the National Academy of Sciences in the development of the whole program, as well as the dissemination and organization of all activities.
- The development of the IBSE Project.
- Support from IANAS and continuous communication between the Focal Points.
- Cooperation agreements between academies.
- Previous training of science researchers from OBMC.
- The commitment and voluntary work of the OBMC researchers, the operating arm of the program, in their role as scientific monitors.
- The permanent use of the Academy of Sciences' facilities for conducting workshops and training courses.
- The agreements with educational institutions, the La Salle and Salesian Universities, Science Teachers' Associations, Private Schools' Associations, non-governmental organizations such as Cuna, Intervida, World Vision, demonstration classes at schools, participation in Educational Project Fairs.

b) Difficulties

- Time constraints for monitoring and accompaniment
- Changes in the monitoring team due to study leave

Plans for future activities

1. Agreements to strengthen the "Science Goes to School" Program with institutions linked to education for the development of extra-curricular activities:
    - Natural History Museum for guided tours
    - National Herbarium for the development of learning experiences
2. Continuation of training courses and workshops on inquiry-based methodology with an emphasis on mental processes
3. Development of a new guide text on experiments in natural sciences and mathematics at the secondary school level
4. Agreements with universities for post-graduate courses in research

3.15 The case of Cuba[20]

The case of Cuba is unusual, which is why we have left it to the end. Of all the Latin American countries, Cuba is undoubtedly the one with the best education. It is an unusual case where academics are also concerned with teaching and dissemination as we shall see in the following report.

Two major international conferences are held in Cuba every other year: one on Science Pedagogy and one on Science Didactics, where the Cuban Academy of Sciences has offered pre-event courses for hundreds of teachers, not only from Cuba but also from other countries in the region on the issue of how to teach science and mathematics outside school. The scientific program of these conferences has also been responsibility of the Symposium of Scientific Culture and Teaching Science through Informal Methods, which incorporates academics (from a committee established for this effect in 2010) and the experiences of the teachers, scientists, university professors and other national institutions such as the Youth Technical Brigades, journalists and communicators of science and technology in the media and, of course, the experiences in aquariums and botanical gardens, etc. The *Juventud Técnica* journal, 20,000 copies of which are printed monthly, has been an ally in these efforts to motivate young people with scientific issues, and is also read by teachers.

International exchange has been important for all activities, especially those of the Children and Youth Science and Technology Festivals, for which support has been provided by the UNESCO office in Havana. Also important was a project developed by the Cuba-Venezuela exchange, in 2009-2010, called Science for the People, which enabled us to acquire mini-planetariums and materials for low-cost interactive experiences.

More recently, Cuba participated in the International Council for Science (ICSU) Regional Committee, whose priority is math teaching. In conjunction with this committee, a workshop was held in Havana in January 2015, with the participation of over 200 Cuban teachers and we have experienced Mexico's Science at Your School, the introduction of the minimum standards or concepts math teachers should know, according to the Chilean experience and the experience of a successful Public Mathematics Olympiad in Paraguay.

Cuba has benefited most from the IANAS Program through learning about new experiences from other countries, which we have gradually promoted. IANAS's support has been crucial because it has opened up a very important window for Cuba in which together, we were able to "roll up our sleeves" and achieve a genuine network of experts with the vocation and ethical and moral commitment to improving the quality of science education in the region.

IANAS has been a pioneering organization and a founder, which, from the outset, realized that science teaching was a key area. It has encouraged the transfer of IBCE techniques and more recently Science, Technology, Engineering and Mathematics (STEM) to less developed countries in the area.

Collaboration with the IANAS Program has been crucial to the Academy. In Cuba, strategic alliances and key support have been provided by the Academy of Sciences, the National President's Office of the Youth Technical Brigades, the UNESCO Office in Havana, Havana University, the Grand Metropolitan Park in Havana, the Directorate of Science and Technology of the Ministry of Education and the Enrique José Varona University of Pedagogical Sciences.

The Science Promotion Group of the Cuban Academy of Sciences has developed low-cost teaching materials, with disposable materials based mainly on the interactive games designed and shared without copyright by the Indian scientist Arvind Gupta, winner of the TWAS Prize for the Popularization of Science 2011.

The Advanced Institute of Industrial Design, with a physicist as its leader, has developed novel,

20. **Óscar Álvarez Pomares,** Focal Point Cuba, Cuban Academy of Sciences.

interactive science prototypes with attractive designs, which it takes to the activities we organize with various institutions. The experience of flying rockets using plastic soda bottles, has been very interesting, since, in conjunction with all the other interactive toys, it has been used to explain physical phenomena.

We also have "The Chemistry Box" designed by a teacher who has had community experience with chemistry in the community and the kitchen. An Origami expert gave summer courses on the topic of Origami and Sciences, which have been in great demand at the festivals we organize in parks and open spaces. The Botanical Society, and the Physics, Chemistry, Meteorology Societies have been very proactive and participatory in these efforts.

However, it must be said that the IBSE has not been adopted in Cuba with that name, as can be seen in all the actions described, which are based on meeting the objectives, actions and agreements of the IANAS Program. Impacts have been achieved, especially in the way we teach science and at the discourse level. The program has also influenced the views of the teachers, methodologists and directors involved in improving Cuba's education system. Scientific societies, universities and the Ministry of Higher Education have also enabled university outreach departments to appropriate these ways of teaching science outside the classroom.

The Commission for Scientific Culture and Science Teaching of the Cuban Academy of Sciences and its Promotion Group were founded on the basis of the IANAS Program.

In Cuba, debate and knowledge of STEM and its methodology is still restricted to a few experts. It has not been disseminated or appropriated by the departments responsible for making decisions on science and technology or education. Extremely incipient exchange experiences have begun with other countries in the region.

Science Academies play a key role in advisory and consultancy functions for governments and society in science and technology. However, it is only recently that many countries have begun to show the will and conviction to task them with contributing to the promotion and advancement of science and the scientific and humanistic training of the new generations.

In 1996, Decree No. 163, which re-founded the Cuban Academy of Sciences, described its functions, which are perfectly in keeping with the issues covered in this book. This fact highlights the clarity of the Cuban directors and scientists who drafted this document, envisioning and expressing the concepts and missions that should guide the Academies' work. The most interesting of these is Article 3, reproduced below:

Article 3. The Cuban Academy of Sciences will have the following powers and functions in order to fulfil its objectives:

a. Contribute to raising the role of science in national culture and to the dissemination of the scientific method in society;
b. Contribute to raising the scientific and technical level of the human potential of the country, especially that of the young generations;
c. Develop various ways of communicating advances in national and international science and encourage them to be incorporated into general and popular education, through coordination with different agencies, and organizations and the improvement of the plans and programs in the national education system;
d. Promote activities that encourage interdisciplinary relations and boost the potential of less developed countries, through the participation of scientific societies.

May 2010 saw the founding of the Group for the Promotion of Science of the Cuban Academy of Sciences, precisely to comply with the provisions of Decree Law 163 of 1996 and to contribute to raising the scientific and technical level of the country's human potential, particularly that of the young generations.

The founding document of the Cuban Academy of Sciences (ACC) Commission for Scientific Culture and Science Teaching clearly expresses the need to encourage members of academia and Cuban scientists in general to contribute to the quality of teaching.

The Commission's Mission

Ensure that the scientific culture of the population is recognized as a factor in human welfare by promoting nationwide actions, while encouraging students in general education to learn science, in collaboration with academic entities, and others whose mission is primarily the creation of a general, integral culture among children, adolescents and youth.

Main task of the Commission

Develop as objectively as possible a *Program of Scientific Culture and Science Teaching* designed to contribute rationally and feasibly to ensuring that the country's scientific potential systemically complements the work undertaken by various institutions to raise the general culture of our people.

The Group for the Promotion of the Cuban Academy of Sciences and the logistics of all the activities it undertakes are financed by the Academy's budget, which is obviously insufficient, meaning that extra funds must always be procured through projects or actions with other institutions

3.16 The case of Ecuador[21]

The Academy of Sciences of Ecuador (ACE) was established on February 14, 2013 with the approval of its Statutes and the approbation of the Secretariat of Higher Education, Science, Technology and Innovation (SENESCYT). Since then, several initiatives have been developed, both nationally and internationally. In the international sphere, one of the first initiatives of its six founding members was to achieve the collaboration of the Inter-American Network of Academies of Sciences (IANAS) for the incorporation of the first 25 new members on February 19, 2015. Thereafter, the ACE was better able to participate proactively with IANAS. This also made it possible to appoint Drs. Guillermo Paz-y-Miño-C and Avelina Espinosa as Focal Points and participants, respectively, to attend the IANAS Meeting of Focal Points of Science Education, held in Mexico City on June 18 and 19, 2015. The message conveyed to the ACE by its representatives was: "First, to continue with the dialogue with SENECYT and strengthen the already good relations, so as to project it to the Secretariat of Education and the future … and then to lead the issue of "Teaching Inquiry-Based Science," within IANAS. I suspect, based on the dynamics of the meeting in Mexico, that Ecuador has a great deal to offer "(Paz-y-Mino-C, 2015).

The presentation by Dr. Guillermo Paz-y-Mino-C addressed the issue of the use of Inquiry-based Science by the Ministry of Education (MINEDUC) in Ecuador. It is not clear to the ACE whether Inquiry-Based Science Education (IBSE) is commonly used within the Ecuadorian system of education, although it is mentioned in the Education Secretariat's brochure, which was distributed at the IANAS meeting (MINEDUC, 2012: 101) and in another MINEDUC publication, with teaching guidelines, (MINEDUC, 2012: 54), which reflects many, if not all, the aspects of IBSE. It is worrying that is not easy to find new documents reflecting the progress in these areas, which may mean that its implementation has been slower than the Education Secretariat would have wished.

Unfortunately, none of the proposals submitted to the ACE had prospered at the time of Ecuador's recent participation in Santiago de los Caballeros, Dominican Republic, on October 6 and 7, 2016,

21. **Jaime F. Cárdenas-García,** Focal Point Ecuador, Member of the Academy of Sciences of Ecuador, University of Maryland –Baltimore County-USA.

where Dr. Jaime F. Cardenas Garcia was appointed as Focal Point for the ACE. The first proposal failed because there were no ACE initiatives designed to involve Ecuador government institutions; the second may not have prospered due to the overestimation of Ecuador's ability to exercise this leadership within IANAS by Ecuador, based on the Ecuadorian experiences reflected in the two publications mentioned earlier. It is not clear to ACE what the scope of the development of Basic Science teaching has been in Ecuador. At the same time, basic sciences are almost nonexistent at Higher Education Institutions (IES) in Ecuador, which in turn affects the training of teachers at elementary and secondary school levels. A recent publication on Basic Sciences in Ecuador notes that in 2014 only 55 people graduated from the country's higher education institutions in all the Basic Sciences (Cardenas et al, 2014: 27).

This problem with basic science teaching was overwhelmingly proved by the fact that the newly-founded National University of Education (UNAE, March 31, 2014), one of the four flagship HEI recently inaugurated by the current government does not have Basic Science Departments to at least meet the basic function of properly training teachers in these areas at all three levels taught in Ecuador: Initial Education, General Basic Education and General Unified Baccalaureate. Moreover, after having operated for two years, the UNAE has a total of just 200 students. Its Basic Education program comprises Mathematics, Language and Literature, and Basic General Education. This may reflect a lack of interest in professionalizing teachers in all branches of basic sciences. The evident lack of concern in this area is likely to affect teacher training at all three levels: Initial education, General Basic Education and General Unified Baccalaureate.

This is where IANAS's cooperation could be decisive as a result of its extensive experience in many Latin American countries. The ACE must begin effectively demonstrating interest in IBSE and its development in Ecuador. One way to do so is to develop a strategic plan that will initially include an analysis of the effectiveness of the current Ecuadorian curricula in MINEDUC, and the role that the ACE can play within that reality, with the collaboration of IANAS and the use of the latter's materials.

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3.17 The Case of Dominican Republic[22]

From the moment the Academy of Sciences of the Dominican Republic found out about the experiences derived from the implementation of the Science at School Program, it realized it was a teacher training method with the potential to revolutionize the country's science teaching. Overcoming difficulties, neglect and lack of resources, it has made progress with the country's institutions. Although virtually no actions have been implemented in the past year, an Educational Revolution is being promoted in the country. This is an ideal scenario for considering the offer of our Academy of Science with the support of like-minded institutions in the region.

Educational structure

The Dominican Republic has faced severe limitations in its educational level due to the poor allocation of resources and insufficient care for decades. In 1997, following the passage of the General Law of Education No. 66-97, which replaced Law 2909 issued in 1951, a process of modernization and updating began which not achieve either the enormous dynamic or support it received in 2012 with the arrival of President Danilo Medina, who promised to promote and develop the sector. According to the Law, the system is regulated by the Ministry of Education of the Dominican Republic (MINERD) and the Constitution enshrines the right to education of all citizens.

In October 2013, the National Council of Education (CNE) introduced a key modification into what was then the Dominican Education System Structure for the Initial, Primary and Secondary levels, which became: Initial Year, during a year of pre-primary school, Primary Level, from first to sixth grade, six years and Secondary Level, from seventh to 12th grade, another six years. This new structure was based on:

a. The importance of matching education levels to students' levels of development,

b. International trends and the need to facilitate the comparison of statistics and education results.

The new structural organization at Primary Level excluded children ages 6 to 12; this stage was known as "Concrete Operations". At the Secondary Level, known as "Formal Operations," the technical organ of MINERD included the teenage population ages 13 to 18. Due to this reorganization, the national education system was aligned with the world's main systems-it should be noted that international tests are also designed for the structure referred to.

This restructuring was gradually implemented as the corresponding curricula were adjusted. Higher education programs were modified, as a result of which the teacher training programs taught at the Institutes of Higher Education were adjusted to the new age structures. At the same time, a process of Curricular Review and Updating was launched, with set deadlines for each level.

As a result of the shortcomings in the education sector – as regards facilities, teachers and potential access in general – coupled with poverty levels of over 40%, the state has not had an instrumental policy to enforce compulsory education, as stipulated by the law. Moreover, free public education has not been available to everyone in the various regions or the most marginalized areas, which has begun to change with the program to build thousands of new classrooms launched in 2012.

Likewise, university education, controlled by the Ministry of Higher Education, Science and Technology, according to Law 139-01, has a state university-the Autonomous University of Santo Domingo (UASD), the Primate of America, and over 40 private university centers with technical, undergraduate and graduate programs, including higher education institutes with advanced technical degree courses.

Resource Assignment

In the region as a whole, Dominican Republic was the country that invested least in public education between 1990 and 2010. In 2011, the total sum invested in education, including private pre-

22. Rapporteur: **Eduardo Klinger Pevida**, Focal Point, Academy of Sciences of the Dominican Republic

university schools and private higher education institutes, accounted for just 4.4% of GDP. The level of public-private investment in education was 24% less than the average invested in public and private expenditure in Latin American countries at the end of the first decade of the 21st century. Until 2012, the proportion of private expenditure on education of the entire expenditure in this sector was the highest of all the Latin American countries.

This has begun to change since the government for the 2012-2016 administration has been complying with the legislative mandate to allocate 4% of GDP to education. During its first three years, these funds were mainly used to provide the sector with the physical infrastructure it lacked, expressed in the construction of tens of thousands of classrooms throughout the country. Of the 2014 budget for educational activities, the government assigned RD$ 105,980.3 million to basic education (approximately $2.4 billion USD at the current exchange rate), equivalent to 97.1% of what had been budgeted for the year (Budget Directorate).

The massive scale of the building program and the various tasks simultaneously undertaken have obviously elicited a great deal of criticism and highlighting of deficiencies, which it is hoped will be overcome in time. For the ACRD, it is encouraging that the designs for building new schools have contemplated the provision of laboratories for the study of sciences.

Indeed, MINERD, encouraged by the strong state and budgetary support it is receiving within the framework of a growing social awareness, together with a flood of demands, about the urgent need to reform the education system and promote scientific knowledge, has undertaken actions to improve teaching quality. Beginning in 2015, the government announced a program designed to attract talented students who would be willing, through the provision of grants, to be trained as teachers in the areas of natural sciences and pursue degrees in similar fields.

Status of the study of science subjects in the country

When it began to work with the Science at School Program, to which ACRD was initially introduced by the Mexican Academy of Sciences, it began to undertake an initial survey, entitled "Perception of Science and Technology in High School Students in Dominican Republic and the province of Santo Domingo," in two stages: the situation of students in several of the country's provinces, namely the National District and Greater Santo Domingo in the first phase, and Monte Plata, Santiago Rodríguez, Hermanas Mirabal and Bahoruco in the second phase. The study was sponsored by UNESCO and undertaken by Gallup Dominicana. (ACRD and UNESCO, 2013).

Although it did not include the whole country, the fact that it included the capital city and its immediate surroundings as well as provinces ranked among the poorest in the country means that the results can be said to be fairly representative. The results could not be more disturbing and disappointing: misinformation, indifference and very little inclination to study science degrees.

Only 5.8% mentioned science and technology, and cited scientific professions as being the lowest ranked profession except for politicians. Over 50% of respondents felt that these degree courses were "for the rich" because, according to 42%, "You can't get a job with that," while 21% added, "You don't make money with them." The lack of motivation derived from low-quality teaching is reflected in the fact that 30% said that these were "boring or very boring degree courses." Only 8.8% of high school students in the National District and the province of Santo Domingo admitted to being interested in science and technology, while just 2.4% said they wanted to choose a scientific degree course such as biology, chemistry, meteorology or astronomy and a mere 0.5% said they wished to become scientists. Only 1% wanted to study biology and none of them were planning to study mathematics as a university degree course work in physical sciences or mathematics (ACRD and UNESCO, 2013).

In 2013, of the 80 students who sat a math exam-all high school graduates with good grades-as an essential requirement for earning scholarships to study abroad, only 29 passed (*HOY*, 2013).

There is a national consensus that science teaching is "poor quality". A former Minister of Education admitted that, "96.7% of students at primary and secondary levels do not pass their Biology, Physics, Chemistry, Mathematics and Spanish

Language exams." (ACRD, 2013). The consequences affect universities.

Of a total of 2,981 students graduating from UASD in 2012, only 12 came from the area of science: two biologists, no chemists and no mathematicians. It is impossible to aspire to development with this structure for training for professionals.

A highly significant moment that permitted (another) diagnosis on the state of national education in an internationally comparable scheme was the country's incorporation into the Programme for International Student Assessment - PISA - in the 2015 process, together with other 64 countries. Two thousand four hundred students were evaluated at 57 selected centers across the country. Business Action for Education - EDUCA - estimates that becoming incorporated into this international evaluation process is significant for the "establishment of a national assessment culture" in accordance with the provisions of the National Pact for Education Reform (*Diario Libre*, 2015: 21).

Science at School

The Science at School Program focuses on the primary and secondary levels and is designed to promote the accompaniment of science teachers to contribute to their professional development and the implementation of a teaching model that interests students and inclines them to scientific knowledge and its potential in today's world. ACRD has prioritized this aim, in the awareness that failure to achieve it will make it impossible to overcome the current situation whereby high school students finish school without elementary basic science skills.

In 2007, the ACRD jointed the Inquiry-Based Science Education Program, known as the IBSE method, thanks to the generous invitation by the Mexican Academy of Sciences to sign a bilateral cooperation agreement to implement IBSE in the Dominican Republic, for which it offered valuable assistance.

This initial impulse were joined by other important collaborations in the form of technical resources, training, consultancy and even modules for classroom laboratories - the Mexican Academy of Sciences donated 30 laboratories and Brazil five – and other forms of assistance from the Interacademy Panels (IAP), The Inter-American Network of Academies of Sciences (IANAS) and the OAS/FEMCIDI program. The latter two have financed the participation of 24 high-level experts contributed by IANAS to provide workshops and conferences for Dominican teachers. The experts were drawn from the Academies of Sciences of Argentina, Brazil, Chile, Colombia, Mexico and Venezuela. The French Academy of Sciences has cooperated with training for teachers and technicians and the United States also contributed, as did the Chilean Ministry of Education.

ACRD began to take steps to generate an internal movement in the educational sphere that would open avenues for the implementation of program, not without having to overcome occasional disbelief and lack of interest and insufficient national support. In February 2009, ACRD signed a cooperation agreement with MINERD that allowed actions to be carried out at a certain level with the technical team of the Vice Ministry of Management and Decentralization.

A National Committee was subsequently formed with the state university (UASD), the private university Pedro Henríquez Ureña (INPHU), the National Council of Private Enterprise (CONEP) and the Institute of Development and Integral Health (INDESUI), an NGO with experience working in schools and training teachers.

After 262 Dominican teachers had been trained by Mexican specialists, a Pilot Plan was designed, whose first phase covered 10 public schools and two experimental secondary schools. With the backing of the National Support Committee, ACRD, in conjunction with several schools in the region, enabled six cycles of seminars and workshops to be given, which were attended by 894 teachers and experts from the MINERD. Nineteen Dominican teachers have successfully completed the Distance Diploma Course offered by the Mexican Academy of Sciences, thanks to 25 grants provided in 2015.

In addition to this training provided in the country, another 40 Dominican teachers and technicians from both the Ministry of Education and universities and another eight members of ACRD participated in training and other teaching experiences in several countries where IBSE is being implemented, such as: Mexico (40), Chile (3), Venezuela (1), Brazil (1), Argentina (1), United States (1) and France (1).

After the Pilot Plan Phase, another set of schools was incorporated into the program comprising 14 from Santiago de los Caballeros – the country's second largest city - and 12 from the province of San Cristobal, adjacent to the capital city.

ACRD sent a technician to the Mexican Academy of Sciences in 2012 to be trained in the use of INDÁGALA -a program for the dissemination of knowledge and the exchange of experience between the region's science academies – in order to enable the Dominican Republic to participate.

Educational revolution

Officially, the government of President Danilo Medina (constitutional period 2012 to 2016) considers that the country is undergoing an educational revolution due to certain unprecedented decisions in the country's historical and political reality, such as the fulfillment of the legal mandate to allocate 4% of GDP for pre-university education. which has enabled the construction of more than 10,000 classrooms – the same number of which will be constructed in 2015 – which will begin to address the critical lack of proper infrastructure for basic and secondary education throughout the country. This has been accompanied by actions to ensure school breakfasts and lunches - solving another of the shortcomings due to the broad sectors still living in poverty, in addition to the implementation of the Extended School Day, (8-hour sessions), in which nearly 40% of students enrolled in the morning shift already participate. At the same time, the "Quisqueya Learns With You" adult literacy program has been successfully launched to eradicate the problem of illiteracy, one of the major pending social issues facing the country.

The Ministry of Education will now focus more resources on raising teachers' academic standards and improving the training of new generations of teachers in order to make the country a benchmark for the region due to the quality of its education. In addition to the authorities, civil society regards the low scores received by the national education system in international assessments as an embarrassment.

Accordingly, the president has pledged to achieve what he described as an "educational revolution" focusing on the promotion of quality. The priority that has begun to be given to the development of the national education system enabled the signing in early 2014 of a wide-ranging National Pact for Education Reform as an expression of the social consensus on the educational level to which the country aspires. This agreement therefore focuses on three main axes: inclusion, quality and relevance.

Indeed, it is impossible to ignore or underestimate the effort that has been made to improve teaching quality. In his State of the Union Address to the National Congress in 2015, the president stated that, "From now on, our main objective should be the quality of education," so that each of the "eight hours count" and "sound education is provided, in keeping with the times." It seems that this route has indeed been taken, since in 2014 2,333 million pesos - approximately $52.3 million USD at the official exchange rate at the time – were allocated for teacher training, a record amount. That same year, 1,670 teachers were able to pursue postgraduate studies and another 5,000 are expected to begin soon. Also in 2014, calls for applications for permanent teaching posts were issued. A total of 17,226 candidates applied and 6,224 were hired. Teachers were given the largest pay raise in 15 years as an effort to increase the value placed on their social function.

Within the framework of this objective, MINERD experts are working to redesign the curricula so that they are based on the development of "skills and knowledge for the individual's full development".

At this positive national moment for the development of education, the Academy of Sciences considers that it is time to make its voice heard by institutions, so that the plans to redesign teacher training incorporate the principles and objectives contained in Inquiry-Based Science Education (IBSE).

Given its conception and design, in addition to having as a reference the results obtained in a sizable group of countries that have implemented it, the key objectives urgently required by national education and development goals could be drawn from the program. A comprehensive reform of the teacher training program would be enhanced by improving training for new and in-service teachers, to enable them to encourage knowledge and interest in the study of scientific degrees among pre-university levels.

There is an urgent need for the national system to improve reading comprehension, individual analysis and teamwork and channel curiosity into the formation of an innovative spirit.

Use by ACRD of the collaboration received and other actions undertaken

As soon as ACRD was offered the opportunity to become involved in the implementation of the Science at Your School program by the Mexican Academy of Sciences, it realized that this was an ambitious project and undertook institutional and operational actions to make the best use of the method, identifying it as having great potential for the country's needs. An ACRD Education Commission was created, which has been joined by a significant number of members interested in collaborating and creating actions that will contribute to the process.

The steps taken and actions taken to implement the program in the country are summarized below.

Results

- To date, this program has been undertaken in 39 schools located in four provinces. The approximate number of teachers and technicians trained is 486
- Nineteen teachers have successfully completed a year-long, on-line Diploma Course in Sciences, taught by the Mexican Academy of Sciences.
- Forty-eight teachers, technicians and academics from MINERD, UASD and UNPHU and ACRD have received training and participated in teaching and academic activities in Mexico, Venezuela, Argentina, Chile, Brazil, USA and France.
- An initial, two-stage study was carried out on the perception of science and technology in students from the National District and Greater Santo Domingo, as well as four other provinces (Monte Plata, Santiago Rodríguez, Hermanas Mirabal and Bahoruco), sponsored by the Commission on Basic Sciences and Technology of the ACRD and the United Nations Educational, Scientific and Cultural Organization (UNESCO), through its office in Havana, Cuba.
- The ACRD produced two newsletters on the program.
- MINERD published a summary of the impact of IBSE in the *Letras de Educación* journal in 2011, signed by the Coordinator of the Dominican IBSE program at the Ministry of Education.
- An ACRD technician was integrated into the INDÁGALA work team to act as a source of information for Dominican teachers in order to facilitate access to this website with information on everything related to the IBSE program in the region.
- A first National Workshop on science and technology policy recommendations for high school students in the Dominican Republic was held in 2013 at the Academy of Sciences of the Dominican Republic, sponsored by UNESCO.
- A total of 532 teachers, technicians and academics have received training in the IBSE Method: 486 at the national level and 46 abroad.

A brief summary of the institutional steps taken by ACDR as part of the promotion of the IBSE program and the activities in which it has participated is given below:

Institutional

- The formation of a National Committee, comprising ACRD, and a state and private university, a business association and a specialized NGO (2008).
- The signing of an Interinstitutional Agreement between the Ministry of Education (MINERD) and the Academy of Sciences of the Dominican Republic (ACRD).
- Second signing of the Cooperation Agreement between Mexico's Secretariat of Public Education (SEP) and the Mexican Academy of Sciences (AMC), and the Academy of Sciences of the Dominican Republic (ACRD) (2011).

Executive

- Workshop organized by the Academy of Physical, Mathematical and Natural Sciences of Venezuela (2008).
- International Congress of Teachers, Professionals, Schools and Elementary Schools in Chile (2008).
- Training workshop. "Science at Your School" Program, Mexico (2009).

- 1st Cycle of Workshops, for the beginning of the "Teaching Science at School Program." Santo Domingo (2009).
- "Science at Your School" Training. Mexico (2009).
- Inquiry Based Science Education (IBSE) Teacher Trainer Training Course. Brazil (2009).
- Science at School Camp, Mexico (2009).
- II Series of workshops on "Teaching Science at your School," Santo Domingo (2009).
- 1st Latin American Congress of Basic Education Science Teachers. Chile (2009).
- III series of workshops on "Teaching Science at Your School," Dominican Republic (2009).
- Circulation of the two studies on the Perception of Science and Technology in students in the National District and Greater Santo Domingo and four other provinces: Monte Plata, Santiago Rodríguez, Hermanas Mirabal and Bahoruco (2010 and 2012).
- VII Focal Points' Meeting, Rio de Janeiro, Brazil (2010).
- Latin American Workshop on Teaching Science at the Secondary Level, and Focal Points meeting. Buenos Aires, Argentina (2010).
- 2nd Latin American Congress of Basic Education Science Teachers. School, Science and Citizenship. Chile (2010).
- IV Science at your School Workshop. Dominican Republic (2011).
- Summer Camp, Mexico (2011).
- II International Congress on Educational Parallelism in Science at your School. Presentation of certificates to the students of the on-line diploma course awarded by the Mexican Academy of Sciences (2011).
- 3rd Latin American Congress of Basic Education Science Teachers. Chile (2011).
- Training workshops for teachers. Dominican Republic (2011).
- Diploma course: Optional On-line Computer Course: Basic Writer.
- Meeting of technical representatives of INDÁGALA. Mexico (2012).
- IBSE Workshops. Dominican Republic (2012).
- IBSE Conference in Santiago de los Caballeros, Dominican Republic (2013).
- Introductory lecture on the IBSE Method. Dominican Republic (2013).
- Workshop to monitor results of the studies on the perception of science and technology among high school students by the Commission of Basic Sciences and Technology of ACRD and UNESCO. Dominican Republic (2013).

Academy of Sciences of the Dominican Republic

An education system is essential for a society to reduce social inequalities and created equity by achieving development goals. The objectives of the 2030 National Development Strategy – NDS- will be impossible to achieve unless the country has population with a contingent of professionals in the fields of basic science who can support the development of levels of competitiveness and innovation itself.

Improving teaching quality, especially at the pre-university level, is the most urgent challenge for an education revolution. This requires assessing teaching staff, as well as their qualifications and training, and providing them with the most modern, internationally proven instruments to stimulate and promote student interest in research. With the movement that has been unleashed, and the horizon to be achieved, we cannot risk ending up with more of the same. The ACRD Education Commission is developing a set of actions that have helped bring teachers into contact with the ACRD's work.

ACRD, with over eight years working to promote IBSE in the country as a science teacher training tool based on the promotion of research, laboratory management and other experiences in which students and teachers can interact, expects to be provided with a space to accompany the authorities and other organizations in the preparation of a new scheme of teacher teaching and education, which takes into account the potential of the Enquiry Based Science Education as a teaching method with a two-fold goal: improving the quality of science education and motivating students in the sciences through inquiry.

If ACRD manages to take into account the benefits of IBSE, it would make a great contribution to science education and therefore to the country's future. Accordingly, taking advantage of the favorable context, ACRD seeks to promote an information offensive to persuade the Ministry of Education to incorporate IBSE principles into its teacher evaluation and training plans so that we are providing science teachers with effective, internationally proven skills, particularly at the primary and secondary education levels. The INDAGALA program is essential. It should therefore be reactivated and all the countries in the region should contribute to its renovation, extension and deepening.

The country is undoubtedly at a unique stage in the reformulation of the educational system, which focuses on teaching quality. This provides the Academy of Sciences of the Dominican Republic with an unprecedented opportunity to collaborate in elementary and secondary school teacher training. This could be a golden moment for regional and international academic institutions that have so generously been collaborating and supporting work in the country, to take the initiative, since the current stage of the national process could result in a laboratory with international impact. This the area on which the ACRD wishes to focus.

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3.18 The case of Uruguay[23]

The National Academy of Sciences Uruguay (ANCiU) Sciences was created in 2009 to cooperate to achieve the highest level of science education in all branches of education. It joined the IANAS Science Program in 2012, contributing to the efforts of this organization to implement IBSE methodology in the Americas.

Although this methodology is not unknown in Uruguay, its use in science teaching at the elementary and secondary school level has been limited and sporadic. Accordingly, in 2016, the ANCiU resolved to promote and sponsor the use of IBSE methodology, incorporating it into its actions in the area of science education in the country.

For some time now, the scientific community of Uruguay has been undertaking actions to promote science, giving courses and workshops for elementary and secondary school teachers and various activities designed to work directly with students at schools across the country. In many cases, although IBSE methodology is not used, current teaching practice could easily be adapted to it. This would make it possible to take advantage of existing experience.

At this early stage, ANCiU will promote this methodology by liaising with national education authorities, contacting academies that have already consolidated experiences and local university actors engaged in similar activities in the various scientific disciplines. By sponsoring IBSE, it seeks to extend the use of the methodology through workshops for elementary and secondary school teachers. In this regard, it is understood that the use of online tools will permit the efficient incorporation of the methodology, using the resources available at Uruguay's educational establishments.

23. **Eduardo Kremer,** Focal Point Uruguay, Full Member of the Academy of Sciences of Uruguay (ANCiU), Professor of Inorganic Chemistry, Faculty of Chemistry, University of the Republic (Montevideo, Uruguay).

The use of technology facilitates access to materials and contents

It provides spaces where IBSE enables students to explain the world around them.

"To promote and disseminate IBSE information between the scientific community and teachers from various Latin American countries"

4

Indágala: The IBSE program website[1]

In 2007, the Andrés Bello Agreement was signed between the Academies of Sciences of France, Argentina, Brazil, Chile, Colombia and the University of the Andes in Bogotá in order to create an Internet portal in Spanish and Portuguese for science education at elementary school, for Latin American teachers to support inquiry-based teaching programs. Months later, the Academies of Sciences of Bolivia, Costa Rica, Mexico, Peru, Venezuela and the SENACYT in Panama were incorporated into this agreement.

This portal was designed on the basis of its French counterpart, La main à la pâte.

In 2009, the Annual Indágala Meeting was held in Venezuela, where it was agreed that, in addition to managing and hosting the portal, the Mexican Academy of Sciences would submit a proposal to redesign it.

Two years later, the Indágala Framework Cooperation Agreement was signed in Mexico by the Academies of Sciences and an Academic-Technical Committee was formed so that the Mexican Academy of Sciences would develop a new proposal for the portal that would be responsible for promoting and disseminating IBSE information among the scientific community and teachers from the various Latin American countries. The following year, the Mexican Academy of Sciences held the first Indágala Technicians' Meeting to train those who will be responsible for uploading the materials produced in the various countries onto the site. An initial operating manual was prepared for the website and, at the end of this meeting, the Mexican Academy of Sciences uploaded the new Indágala website.

Continuing with the evaluation policy, the page was evaluated. The results showed that it had very little impact on the community and it was decided to conduct an external evaluation to determine the causes. This evaluation was conducted by a team from INFOTEC, a public innovation and technological development center, attached to CONACYT in Mexico. At the same time, the Science at Your School Distance Learning team undertook an internal evaluation a year after the new site was officially launched. Lastly in February 2014, the Mexican Academy of Sciences organized and sponsored the first Indágala Academics' and Technicians' Meeting on its premises. During that meeting, the results of the internal and external evaluations of the website were announced. An intense collective analysis was carried out by the various academies present and alternatives for improvement were put forward. The most significant of these was the redesign of the site.

In October 2014, at the IANAS Education Program Focal Points Meeting in Lima, Peru, the Mexican Academy of Sciences presented the new site design and proposed the signing of a collaboration agreement that includes the amendments suggested at the previous meeting. This is available at the following website: **http://www.indagala.org/.**

1. **Carlos Bosch,** Focal Point Mexico, member of the Mexican Academy of Sciences, and professor at the Autonomous Technological Institute of Mexico (ITAM).

Experimenting is an exercise that develops thinking skills

Transforming work in the classroom by implementing innovative teaching strategies, encouraging different learning environments and creating our own educational materials is our challenge.

"Make the Inquiry-Based Science Education program a tangible reality"

5

A general overview of what has been done[1]

The main aim of the book that is being presented, largely authored by the Focal Points of the Inquiry-Based Science Education Program, is to attempt to share the experiences of the various Latin American Academies of Sciences since the program's inception. A second aim is to record the ideas and approach put forward by the Academies of Sciences of the countries that are taking the first steps to implement IBSE methodology.

Since the inception of IANAS and in keeping with the spirit of the IAP, science education was one of the main concerns. As already noted, Inquiry-based Science Education (IBSE) was one of three programs with which the Network's activity began. IAP's warning about the precariousness of the way science is taught at elementary school, coupled with successful experiences in the US and France, which were known to some of IANAS's founders, meant that in Santiago de Chile, all the presidents of the Academies participating in the creation and implementation of the Network agreed, on behalf of their academies, to implement the program, assuming the challenge of making their best efforts to improve science education through IBSE.

1. IANAS Science Education Program Focal Points

At that time, the Academies of Sciences of Mexico, Brazil, Colombia, Chile and Argentina already had some experience in this issue. Leaders such as Ernst Hamburger and Dieter Shield in Brazil, Jorge Allende in Chile, Carlos Bosch in Mexico, to name just a few, were aware of the La main à la pâte (LAMAP) program and the US education program based on the initiative of Dr. Leon Lederman and supported by the National Science Resources Center (NSRC) located in the Smithsonian Institute. Other countries such as Bolivia, Peru, Venezuela, Panama and Guatemala had also made efforts to improve science education, but the first experience in the methodology and organization of an IBSE program was in October 2004, when a team of teachers was selected to attend the *Inter-American Workshop on Strategic Planning for Project-Based Inquiry-based Science Education* organized by IANAS in Santiago de Chile.

This workshop, in which emphasis was placed on the meaning of Inquiry-based science education, was also attended by NSRC director Sally Shuler, who showed the type of material used for conducting experiments in the classroom, which was available for purchase that day.

The workshop encouraged several countries to follow the model used in the US for experiments and monitoring teachers in science classes, including the

Academies of Sciences of Chile, Brazil, Colombia, Panama and Venezuela. Others remained closer to the La main à la pâte model and Mexico was always a supporter of providing good teacher training in science, mathematics and language, so that teachers would be able to convey their knowledge in the classroom.

The workshop organized by the Academy of Sciences of Chile was a starting point for the organization of a program to improve science teaching, using the experimentation scheme, in the Latin American region.

We say a Latin American rather than a continent-wide program because of the substantial differences regarding both finances and teacher preparation, between the two largest countries in North America and the other countries in the continent. Three groups of Academies can be distinguished in America with different levels of experience in science education: the first consisting of Canada, the US, Brazil and Mexico, which are Academies with several members and a solid infrastructure for implementing the program. The second comprises Chile, Argentina, Venezuela, Colombia and Peru, with Academies with a limited number of members and a much less consistent infrastructure, while the third consists of newly-created academies, with little economic or structural strength. Although it was not initially thought that these differences would affect the development of a regional program, with the passage of time, the realities have become apparent and had to be accepted.

Another difference evident from the beginning was the financial support that the program could obtain from the countries' respective governments. Differences were visible from the start: whereas the Academy of Chile, for example, had a state budget that allowed it to organize the program very easily, and the Mexican Academy had enough support to train teachers in much of the country, and the Colombian Academy, thanks to an agreement with the Universidad de Los Andes, could also support a number of schools, other Academies found it difficult to launch the program. Not all the countries' programs could be financed with funds from IANAS, because that is not its function, and in any case, it was the Academies' responsibility to obtain the funds required to implement it. But that was not easy either. Relations between the Academies and the governments of the day or private institutions differed from one country to another. Venezuela might be the clearest example of this.

For ideological reasons, the approach of the Science Education Program does not coincide with that of the Education Ministry of that country. Accordingly, the Venezuelan Academy was unable to achieve government support to undertake the program. So two decisions had to be made: on the one hand, the Academy was fortunate to obtain valuable financial support from a private association, the Empresas Polar Foundation, which also expressed a great deal of interest in developing the program, which permitted its implementation; and secondly, it was necessary to limit the number of schools that could be supported. Indeed, not only because of the investment it involves but for reasons of legitimacy, it is not a function of the Academy or of a private company, but of the state to resolve the problem of science education throughout the country. It was therefore decided to keep the program on a pilot scale, with the aim of implementing research methodology in the best possible way in order to improve science teaching at the elementary school level and present it, where possible, to a new Ministry of Education to expand it throughout the country.

Another issue that has influenced the degree of success of the program is the support the Academies of Sciences have given the Focal Points. Indeed, although the Academies have pledged to implement the program, the responsibility for its implementation falls squarely on the Focal Point.

One of the greatest successes of the Academies is having appointed as Focal Points academics who are genuinely interested in science education, and with a great deal of enthusiasm, done everything possible to help their countries improve elementary school science teaching. But not everything depends on what they can do, but rather on the support they receive from the Academies in fundraising and the relationships they can help them establish. And in many cases this has proved ineffective. It is no exaggeration to say that the success of the program depends more on the person in charge, the Focal Point, than on the Academy itself. This is something we should try to change to meet the commitment to join the IANAS program.

We should recall that when Dr. Jorge Allende coordinated the program with Dr. Jose Lozano, funding was obtained from the OAS which was used to give workshops and courses in various countries. However, this is the only funding that has been achieved, beyond what IANAS can offer and distribute out of its budget for the program.

The program has therefore progressed in each country according to its possibilities. The Academy of Sciences of Mexico has maintained its original interest in training teachers; that of Peru has focused on improving mathematics teacher training; the Chilean Academy began by taking the program to several schools, but was stopped by funding cuts by the Ministry of Education, although it is expected to overcome this situation; it is also in the progress of implementing the program at secondary schools. The Academy of Sciences of Argentina maintains its orientation; the Brazilian Academy of Sciences has taken the decision not to continue the program for internal reasons; the Academy of Sciences of Costa Rica is taking over the program from the Ministry of Education. The Academy of Venezuela continues to expand its pilot program cautiously with the support of private enterprise and is focusing more on teaching training; the agreement between the Academy of Science of Colombia and the University of Los Andes has concluded and the program is being revived, while the Academies of Bolivia, Guatemala and the Dominican Republic continue making efforts to train science teachers. Other Academies, such as those of Ecuador, Nicaragua, El Salvador, Honduras and the Caribbean are only beginning to implement the program.

We cannot therefore say that a Regional Inquiry-Based Science Program has been created, or even that this is the best option, which should be discussed by the Focal Points and the IANAS Executive Committee - but we can say that the past ten years have seen the development of the idea to organize activities designed to improve the teaching of science at the elementary level in several countries and that Academies are supporting the initiative through their Focal Points as far as possible.

Throughout the text we have tried to stress the importance of science education, particularly the need to implement a different way of teaching from the one that has traditionally been used.

We all know that education is a long-term process that is always under discussion, since there is a general consensus that it is the basis of the progress of societies. Many reflections, proposals and efforts have been made to provide young people with the best tools and educational practices from early childhood, but the results are always seen in the long term. As has been said since the start, the demands of the modern world require the reinforcement of science teaching in elementary and secondary school education. This is what we are trying to do in Latin America through the IBSE program, sponsored by IANAS and the Academies of Sciences and to a much lesser extent, official education organizations. It is a fact that education in Latin America, with notable exceptions, it is a issue that has mattered very little to governments. Accordingly, this reform of the methodology and the emphasis that must be placed on the educational process is being led by Academies of Science, sometimes against the interests of a particular government.

The objective it pursues is extremely ambitious, since, in addition to the financial resources required, it involves a radical change in the mentality of teachers and above all, of the schools where they are trained, official education bodies and even society itself, which often has very little scientific culture. IBSE is a program that is unable to yield impressive results in the short term, as borne out by the countries that have invested most in its implementation, which also have an educational community with a high level of training.

What can be regarded as an achievement of some significance is that the importance of this new methodology at elementary and secondary schools has been widely accepted and that the Academies of Science on the American continent have pledged to support it as far as possible.

As can be seen from the contributions of the Focal Points, the program has been developed in different countries with specific nuances. Some have tried to adopt the classic version of IBSE methodology, others have focused on teacher training while still others have emphasized certain areas of science. In short, all the Focal Points, with the support received from IANAS and their Academies, have done their homework. Particularly striking is the support certain Academies, obviously those with the most funds, have made available for the implementation of certain programs.

At this point we think it is valid to argue that, while the support of the Academies provides significant endorsement of the program and the guidance and financial support of IANAS are extremely significant, it should be recalled that the progress of the program in each country is largely conditioned by the Academies' commitment to consolidating it and the local support Focal Points receive.

Lessons Learned

In the more than ten years since the inauguration of the program, a number of lessons have been learned.

1. The first is, of course, the need for teachers with a solid grounding in science who are able to spark children's interest in science and also answer questions that arise in class.

   It is therefore essential to devote time and efforts to the planning and development of workshops for teacher trainers and classroom teachers. A more expeditious way of training teachers are diploma courses, such as those offered by the Mexican Academy of Sciences and shortly the Venezuelan Academy of Sciences.
2. The need for teaching materials that are entertaining and, above all, properly prepared for use by classroom teachers and laboratory notebooks for children to record their hypotheses, describe experiments and record their findings. This material can be presented as modules in any way that seems appropriate. But the most important aspect is for them to be freely available for consultation on the websites of the various programs and that of Indágala, and for their use not to be subject to any more restrictions than the mention of their origin.
3. Programs should have a basic logistical support to enable facilitators to carry out their work in schools, while the Academies of Science of the countries that form part of the program are obliged to support the Focal Points in obtaining funds. The program's success depends more on the commitment of the Academies as institutions that have agreed to adopt the program than on the Focal Points. The Focal Point is responsible for coordinating the activities and implementing them with the support of his or her team.
4. The IANAS Executive Committee has the responsibility to ask the Academies to report on the development of national programs.
5. It is increasingly necessary to incorporate mathematics and language development into IBSE programs. It is increasingly recognized that the use of mathematical knowledge facilitates the development of better ways of life and there is no way to share knowledge without the proper use of language.
6. Each program should have a website available to teachers to provide them with effective study materials and teaching methods.
7. Collaboration and the exchange of ideas and experiences between the Focal Points and teachers from different countries are extremely beneficial.
8. It is useful for the program to be linked to other IANAS programs such as Women in Science, Water and Energy, to develop study material on these issues.

Future actions

The most immediate actions should be to continue and expand cooperation between the Academies to develop the program. One outstanding issue is sharing teaching materials between programs that are already operating and the exchange of experiences between teachers from different programs, through, *webinars* for example, or other means based on the Internet.

Diploma courses should be used for teacher training and the Inquiry-Based Science Education Program should be linked to the Women in Science, Water and Energy program.

In fact, an extremely high percentage of school teachers are women and it is important for girls to regard them as an example of the fact that science is not just a matter for men. In many countries, there is still a tendency to think that analytical intelligence or inventiveness are masculine traits, even though this has no scientific basis.

There is an obvious link between Science Education and the other two IANAS programs, Water and Energy. Various levels of the science curriculum include concepts related to these two topics. Consequently, the development of teaching modules using the IBSE approach would be extremely useful. Even more importantly, these modules should reflect the problems and particularities of each country.

Another aspect that should be developed and homogenized in the various programs is the monitoring and evaluation of the achievements of each country, while understanding the realities of each one.

Moreover, it is essential for Focal Points to share the goal of including mathematics and language, if we really think it is important to promote an interest in science at elementary school in order for children to consider it in their future professions.

We also propose an expansion of the program's international relations, specifically through La main à la pâte via the **http://www.indagala.org/** website without excluding other possibilities, and making the best use of the facilities this can offer to strengthen our efforts.

These are just some examples of what remains to be done to make the Inquiry-based Science Education Program a tangible reality.

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