

# SCIENCE BY AND FOR EVERYONE: A NEW APPROACH FOR BRIDGING THE GAP BETWEEN SECONDARY SCHOOL AND UNIVERSITY

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## **Abstract**

*Science by and for everyone Programme provides varied activities through the Centre for Research and Support of Scientific Education (CIAEC). The improvement of both the sciences teaching and learning at different educational levels, attempting on the scientific literacy of the whole educational community is aimed. CET Programme (stands for the Spanish name Ciencia Entre Todos) proposes answers to issues of special significance to secondary school as well as first-year college students. It also addresses the training of teachers, and the advising for the resolution of specific problems in specific contexts. We take in account that it is necessary to establish and consolidate a transforming relationship between the University and society at large through a communicative, educational and scientific program that defends equal access to knowledge and an education for everyone, and contributes to a sustainable development of the region. Different activities related to teaching, research and extension, are linked. We promote training in service for teachers, new practical activities, self-evaluation, and collaborative work. Particularly, we established a team under a network way. The network is useful for thinking, analyzing and evaluating our own problems, in order to explore new answers for those problems.*

**Key words:** articulation university-school, multilevel integration model, teachers training, science teaching, secondary school.

## **Problems of science education in formal contexts**

Nowadays, scholar communities and international organizations such as UNESCO are strongly concerned about the quality of teaching and learning outcomes in all fields of knowledge. Thus, Natural Sciences teaching represents a double challenge for teachers. Hernández and Sancho (1993) stated that “*neither knowing Natural Sciences nor knowing how to teach is enough to teach Natural Sciences*”. In this way, Natural Sciences teaching need a deep disciplinary knowledge with an updated and dynamic vision of those disciplines. It also needs adequate pedagogical strategies in order to offer actual conceptions about its complex nature to the students.

The secondary school (12-17) situation in public schools is particularly very difficult for most of secondary student desertion specially occurs there. The causes are multiple and varied, for example, the need of incorporation to the labor market, the shortage of economic resources to solve educational expenses, the gender discrimination, among others. These situations, usually labeled as “scholastic failure”, affect in a negative way the students’ motivation as well as their families’ and also the teacher’s.

An explanation of the three vertices of the pedagogical triangle could help to describe the problems of natural sciences teaching in secondary school:

a) *Students' profile*. Although science is very important today, young people possess neither the necessary knowledge nor the wishes to work in this field. Indeed for that reason, the access to the scientific knowledge becomes necessary from early age through a system that offers wide information in relation to sciences (Claxton, 1994, Vázquez and Manassero, 1997).

Each generation of students has its own characteristics in agreement with the socio- historical moment that is called on to live. At these moments, children and young people are themselves invaded by an excess of information (of doubtful quality), and they are immersed in an *instant culture* that makes them demand instant gratification in their everyday-life. They coexist with a generation of adults that has been struck and in many cases they have not been able to develop totally in the labor field. This generates displeasure and a disinterestedness that is translated in a lack of expectations with regard to personal formation.

Also, the secondary school original conception did not anticipate the possibility of students' *in* and *outs* of the system. Nevertheless at the moment, this constitutes an additional issue. There are numerous groups of young people or young adults (15-25) who have been outside the educative system with few possibilities to re-enter in the system. The causes of exclusion can be attributed to learning difficulties, indiscipline problems, and economic and/or affective deficiencies. Other reasons point at children engaged to child labor which often interferes with their education and is sadly associated to violence and delinquency. It is required then that educative actions revert the social vulnerability of these marginalized people, so that it would allow the recovery of the personal voice respecting the cultural diversity and the equality of opportunities.

b) *Staff's profile*. Another distinctive characteristic of the secondary level is the teaching staff heterogeneity due to a great extent to its different initial formation. Some of them, initially formed as primary school teachers, were *transformed* for the education in the Natural Sciences Area. Other were trained as teachers in one or several of the disciplines of the Area (Physic and Chemistry, Mathematics and Physic, Natural Sciences, etc.), in non-university institutes generally located far from knowledge production centers. Finally, the secondary school teaching staff also includes University professionals (chemists, physics, doctors, engineers, etc.) that, although they possess a solid disciplinary formation, lack an adequate pedagogic formation.

However, all teachers share a divided vision about disciplinary contents and pedagogical contents. In general, just to mention some of most relevant aspects, teachers possess scarce formation in the Science-Technology-Society-Environmental approach (STSE) (Gil et al., 2006), in epistemological and historical aspects, the construction and application of models, update and prioritization of contents related to the XX (and XXI) century science. Consequently, an update of disciplinary contents and a didactic sequences formulation that transversal subjects require becomes a high-effort activity for teachers.

At last, considering their pedagogical strategies, the teachers do not generally organize the information, are far-off from new information and communications technologies and usually work alone (lonely teachers).

c) *Natural Sciences and curricular materials*.

Yet, in these days certain myths on the difficulty of sciences persist and therefore, science is but for a few chosen ones. Perhaps, for that reason, the curricular designs pay particular attention to Mathematics, Language or History and usually relegate the disciplines of the Natural Sciences Area. In addition, the contents of the Natural Sciences Area usually are dedicated to high level abstraction topics that seem remote to the real-life situations of the students, their problems and interests.

Text books often contribute to this issue displaying great amounts of information to be learned in a short time serving as a curricular organizer (Goldish, 1988). Nevertheless the conventional text book vanishes in front of groups of students from underprivileged contexts that require of appropriate examples not only for their age but also for their particular condition.

As denoted by the previous description of the three main educational issues and taking them

into account the Science by and for everyone Programme (CET Programme, stands for the Spanish name Ciencia Entre Todos) is oriented to the teaching and learning sciences improvement with an integrating approach to contribute to the scientific literacy of the whole community (Lorenzo, 2006). Besides, this Programme considers the importance of the secondary school students' permanence and graduation conditions and their possibilities of access to the University, the staff upgrade as well as the advising for the resolution of specific problems in specific contexts.

Thus, connecting teaching, research and services activities, we contribute to the development and consolidation of the articulation between different levels in the educative system, constructing a place of reference for reflection, the raise of problematic situations and the exploration of answers that lead to the search of actions for the educational quality improvement and the academic excellence.

### **Looking for solutions: A new way for teaching and learning natural sciences**

The CET Programme is coordinated by the Centre for Research and Support of Scientific Education (CIAEC) of the School of Pharmacy and Biochemistry. It belongs to the main University of the country located in the downtown of the capital city.

CIAEC manages a space in the University for teachers and students of all educative levels, in an articulated way with the research-faculties. In this way, it offers different activities in order to exchange ideas, problems and solutions, reflect on them and produce new knowledge (Lorenzo and Rossi, 2007a).

Schools of diverse characteristics participate in the CET Programme. In the beginning, there were five schools. Four years later, there are twelve educative institutions: for children and for adults, primary and secondary school, and for teachers' education. They are located in different cities around 500 km from the CIAEC, and some of them are rural schools.

CET Programme articulates disciplinary contents with a constructivist science teaching approach that allows the teachers and students to get acquainted to scientific work performed at the University. Actions with a propaedeutic character are favoured to facilitate the secondary school students' permanence and graduation and their access to the University avoiding the first year's desertion.

Taking into account the levels of problems described previously, it includes:

a) A set of activities especially designed to stimulate students' interest and motivation considering actual problematic situations. The key topics were selected to maintain a close connection with the students' issues and everyday experience. So, environment, health and nutrition were chosen as pedagogical priorities. The didactic proposal includes netting work between teachers and pupils (Lorenzo et al., 2007), the performance of practical laboratory activities (Lorenzo and Rossi, 2007b). As an example, chemical and physical contaminations of the soil and air topics were included through simple analytical assays such as impurities and heavy metal detection, and pH determination. These activities resulted of particular importance to a group of students of low-income whose main work was garbage recovery. In the case of students from a rural school, they were able to detect fertilizers and herbicides and to discuss about their presence.

b) In order to deal with the problematic of teachers' heterogeneity related to their initial training and science specific knowledge, a new model for their training was implemented. This model is based on our *multilevel integration model* (MIM, Lorenzo, 2008). Initially, a multilevel integrated team (MIT) was constituted by teachers from all educational levels of the participating schools (primary, secondary and tertiary levels). The methodological proposal includes a collaborative and democratic way of working, in which decisions are made by consensus. Basically, the methodology for intervention consists on periodic intensive meetings (two consecutive days) every three months, followed by a transference period and/or classroom implementation. Each MIT meeting nourishes from what has been done up to the moment and projects activities to be performed ahead. Simultaneously, capacitating for the MIT teachers' is offered by specific courses opened to the whole academic community. In this sense, science education problems and their potential solutions are in the core of the teachers' training.

The objectives are to stand by teachers in their questions and to guide them for the construction

of the answers, to favour the exchange between pairs, to stimulate the dialogue and the capacity to listen and to tolerate other opinions. Hence, the teachers can live an existential experience that endorses them to reconstruct their scientific knowledge and to develop their content pedagogical knowledge (Bucat, 2004).

The workshop experience is a significant tool that promotes the investigation of the problematic that each teacher go through by means of an active way, and with an emotional commitment, where they are subject and object of the learning. The workshop allows encountering and then to design devices that favour the overcoming of fears and myths. Central issues of collective discussion are the analysis and the reflection on the classroom's actual situations and institutional practices including a new theoretical framework.

Finally, the teachers can develop their tasks with autonomy and self-manage in the construction of strategies that assure the transference, institutionalization and sustainability of the introduced pedagogical innovations.

This new scene enriched by the joint group-effort fosters a new way for dealing with sciences and its methods giving fresh meanings to their contribution for the development of the cognitive, metacognitive and social capacities of students and teachers.

Very specially, the construction and consolidation of the network challenges the traditional educative practices offering a new way of communication that supports the maintaining the teaching and learning processes. This "netting methodology" is simultaneously implemented in all participant schools. So, this strategy of work favours the optimization of the resources available in each institution and, at the same time, it carries on an articulated network that enriches the individual work with their pairs' contribution. Thus, the sensitization of the scholastic community and committed participation of teachers and students were acquired. Moreover, distance between the University and the schools are shortened through these types of activities, generating a lattice that fed-back the network's results and products ([http://www.ffyb.uba.ar/ciencia\\_entre\\_todos](http://www.ffyb.uba.ar/ciencia_entre_todos)). In this way CET Programme includes information and communications technologies between the network members by electronic mail. Also periodical meetings, telephone calls and postal correspondence are used for the exchange of productions and materials between students of each school.

It is important to highlight that all the innovation proposals foster integration with other disciplinary areas obtaining an effect of scientific literacy of the whole scholastic community.

Furthermore, the conceptions on the evaluation are reviewed. In this case, the assessment is presented as another instrument in the educative practices, acting as a model and as an exercise for the participants, developing their abilities of reflection and self-criticism in order to intervene on their own reality.

## **Outcomes and implications**

The CET Programme is an original experience by the School of Pharmacy and Biochemistry that opened its doors to the secondary school teachers for the first time since its foundation. This fact should not happen inadvertent for it represents an important change in the conception of the role of the University in the teachers' qualification and the improvement of the secondary school.

In particular, a diagnostic evaluation on the implementation of experimental activities was performed using surveys for all the participants (teachers and students) (Lorenzo y Rossi, 2007b). Results showed that experimental activities are either not frequent or structured as "recipes" and/or "demonstrations," missing their didactic potential. Therefore, courses with the purpose of training teachers within chemistry, physics, and biology in the pedagogical aspects of experimental design for student laboratory activities were specially designed. *Teaching of Science: Problems and solutions, Science and Environment Lab, Science and Health Lab, and Science and Research Lab*. They are open to the whole educational community, and they combine a disciplinary training focused on laboratory practice, but they also include seminars and workshops with a pedagogic-didactic design that can be adapted to the classroom. One hundred and twenty teachers attended to these courses. Fifteen conferences in charge of University specialists on different thematic related to science teaching, food contamination, nutrition, and gender discrimination in science, among others, were also dictated.

Several netting activities (5) were simultaneously implemented between 2005 and 2007 (Lorenzo y Rossi, 2008), enrolling more than 900 students from all the participating schools (“A Name for Our Network”, “Air Pollution”, “A Scientific among Us”; Scientific Dishes Fair”). Accordingly, specific materials were designed and printed to accompany those activities. At the same time, teachers’ and students’ participation in scientific and academical meetings were promoted (8 presentations).

## In summary

The application of MIM is a new way to deal with teachers’ capacitation and, consequently, with science teaching improvement. This model redefines the role of University specialist as a traditional “solution provider” from a new insight as a tutor or catalyst for the search and implementation of possible answers. Thus, a qualitative analysis of our outcomes reveals:

Significant changes in the performance of teachers. They have achieved greater initiative to propose and to design new activities. At any time teachers showed a high degree of commitment and an excellent predisposition for team-work and mutual collaboration. At the same time, they gained a more inquisitive and reflective new glance on their own practice.

A larger number of students keep on at school. They have improved their skills for the communication and their interest to learn. A fresh interest for sciences was developed so a new way of articulation with its social community surroundings were established. In particular, belonging to CET Programme, favoured the growth of a greater confidence in those students of the marginal sectors.

Space for science teaching was also enriched. In this way, in a broad sense, the actual class hours for Natural Sciences education were increased. Mostly, the incorporation of classroom experimental activities, the performance of practical and field-works were aspects the CET Programme participants intensely worked with.

The CET Programme was conceived under the belief that a better world is possible: **It can be done!**

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