



Teaching Science at School

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1. The context

The “Chemistry Is All Around Network” [1] is a three-year project funded in the framework of the Lifelong Learning Programme – Comenius sub programme – Networks Action, aiming at stimulating the students’ interest towards the study of Chemistry.

The background for the project has been identified on the evidence of common needs within the eleven countries involved and within Europe in general, related to the insufficient diffusion of scientific culture and awareness that, starting from the school education (primary and secondary levels) affects the whole educational and training systems and, therefore, citizens in general.

It is based on the collaboration of school teachers, scientific experts and university researchers and each year foresees different activities within a specific area of interest: 1. students’ motivation; 2. teachers’ training; 3. successful experiences and good practices.

The first year of work, dedicated to analyse students’ motivation in studying chemistry in the Countries involved, was completed in December 2012 and the material produced (papers, reports, teaching resources etc.) is available in the project portal. The second year, dedicated to teachers’ training, is in progress and the first considerations related to Italy are herein presented.

2. The image of chemistry teachers and their training

Chemistry is recognized by students as one of the most difficult and boring subjects and too often the responsibility of students’ low motivation and performance is assigned to teachers. As a matter of fact, they are considered experts of the discipline, but unable to present it under a more capturing light, or to explain the abstract contents in a more suitable way. It’s a common opinion that they should continuously update their teaching methodology, by using different approaches and tools, in order to satisfy the needs of each student and the changes in society.

These statements cannot be shared by people that work in the field of education and know too well that teachers, not only chemistry/science teachers, do not often receive an adequate preparation and find it difficult to deal with colleagues. When students do not learn it’s just too easy to blame teachers simply arguing that they should find ways to better teach; it is much more useful to know how teachers are trained initially and what is provided to ensure their in-service training.

Teachers, and much more science teachers, cannot be trivial dispensers of information but must become professionals with specific and synergic skills:

- Disciplinary skills. This is a necessary, but not sufficient condition.
- Educational skills related to their discipline. These skills are needed because they make teachers able to plan and cope with learning situations.
- Pedagogic skills. In order to face the complex social and psychological problems that arise within the class.

Actually, the above skills are only partially provided by courses for initial training:

- degree courses for primary school teachers (“Sciences of Primary Education”);
- postgraduate schools (TFA,) for secondary school teachers;

while few sporadic forms of in-service training are provided by national projects as “Scientific Degrees Plan” [2] and “Teaching Experimental Sciences” [3], or by not compulsory courses, essentially



provided by INDIRE Institute (National Institute of Documentation for Innovation and Educational Research), such as the PON Science Education [4].

In order to make teachers “experts of teaching” it is necessary to establish centres of initial and in-service training throughout the national territory and have the total support of the Institutions. These centres should rely on the collaboration of experts in the curricular disciplines, but also in education, psychology and pedagogy; they should also update continuously their research and training offer in order to satisfy the needs of teachers and schools of each grade and level

3. Few guidelines to teach science at school

The teaching of science at school leads to face different situations and problems and to use different tools.

In particular, we will focus on the problem of communication and of the use of the laboratorial approach.

3.1 Communication

The primary task of teaching should be to identify the conditions that can make communication effective; in other words, the most appropriate conditions to minimize the difference between what the teacher means and what the student perceives. This is particularly difficult when the subject taught is chemistry, because of the relationship between the macroscopic and the microscopic models and of the necessity of using symbols.

Three main contents are involved in communication at school [5]: the language, 2. the requisites, 3. students' interest and motivation

The language

Teachers should take the language into a great consideration, despite the discipline they teach: they should use, as much as possible, words of the common language, at least initially (it means starting from the language of their pupils), and, at the same time, they should work to enhance the linguistic skills of their students. Pupils' linguistic problems occur from the beginning of primary school, since the very first day of school: It's when the kids realize that some topics are difficult for them to get through and, thinking they won't be able to understand, they will rather use their memory than their brain to learn. This somehow inevitable choice, is irreversible because if the pupil gets good results by memorizing and repeating, he will continue and become increasingly able at this feature; memorizing requires less effort than understanding, and students will hardly choose this option, particularly those who have never been purposely trained.

The requisites

When the addressees of a message haven't got the necessary requisites to interpret it, this creates problems in communication. In this case, we refer to the conceptual requisites, skills and abilities that are essential in order to understand what is being proposed. For this reason the choice of contents becomes an extremely important factor in school, a factor often overlooked in favour of the method. The method is certainly important but so is the quality of the contents that the teacher offers, as there are contents that need multiple requisites and contents that require the possession of fewer requisites.

The motivation

Once the teacher has created adequate conditions so that the message is understood as the teacher wants, there is the problem of passing from the so-called comprehensibility of the message to its proper understanding by the recipient. Interest and motivation are factors that influence the transition from comprehensibility to proper understanding. As a matter of fact, there is a strong relationship between learning and interest in learning: it could be argued that if pupils have no reasons to understand, the learning will be very hardly achieved. It is necessary to identify appropriate tactics and



strategies to attract the students' interest, to make sure that they feel the need to "look for explanations."

Explanation is strongly connected with problems in communication and it's useful to spend some words to clarify its meaning and role [6].

An explanation about scientific subjects, can be really considered as such, only if the pupils are able to understand it, otherwise it loses its educational value. The teacher, therefore, must always calibrate his/her didactic proposals taking into account the requisites of his/her students: only when the explanation takes into account the cognitive level of the recipients, it can establish a functional communication towards learning. Moreover, it is necessary that teachers, as well as their pupils, are able to distinguish between the explanation of a phenomenon and its description.

Unfortunately, the training that many teachers have received did not favour the acquisition of a critical and reflective behaviour: during their teaching activities they tend to repeat to their students the same 'explanations' stored or partially understood when they were students. As an example, we can consider the transition of a pure substance from the solid to the liquid state: this is a familiar phenomenon and therefore, being erroneously considered simple, it is treated with excessive superficiality also from textbooks that often provide explanations that do not really justify the macroscopic behaviour.

3.2 The laboratorial approach

The laboratorial approach is a very useful tool for teaching to develop the cognitive autonomy of pupils [7]. It is a methodology that valorises the experimental approach to problem solving and enhances its educational potential. It foresees a sequence of actions where the student is not a banal performer that follows the instructions of a recipe, but a person who reflects about the way the experiment should be carried out, performs it, collects data, analyses the results and communicates them. This way of working allows to raise the logical-linguistic skills of pupils, the ability of evaluating their knowledge and the ability to relate to others. Everything can happen only through a systematic request of expressing their points of view, compare them with their classmates' and verify their claims.

The operative sequence to follow during a laboratorial path is the following:

- focus on the specific topic that will be dealt with, through the description or presentation of an experience (this applies in particular to the experimental sciences) or a short written text (this approach is used for all disciplines)
- individual written work: each pupil has to express his point of view about the topic. The work has to be performed by the use of a worksheet where the teacher clearly indicates what is requested by the students. The task usually consists in one or more specific open questions
- written work made by small groups (on another related worksheet): pupils compare the individual answers and try to reach a unique shared answer. Should different points of view persist, they must be written
- presentation of the conclusions by the representatives of each group; the teacher will try to build up a summary of the results
- teacher's considerations about the topic dealt with, additional information and suggestions.

From the above discussion, we can deduce that the laboratorial approach is not trivially a practical experience that students carry out in the lab by following a pre-constituted recipe, but it can consist in a more complex path. Following this methodology, the experimental approach to scientific problem solving consists in designing and performing an experiment, collecting data and analysing results, but also in enhancing pupils' ability to express their points of view, to compare them with those of their fellows and to reflect about what they have done and thought during the activity. In this way pupils increase their self-esteem, their cognitive autonomy and their metacognitive skills.



Finally, it is worth underlining that, if we want motivational aspects, laboratories and other educational tools have a positive role, it is indispensable to realize an efficacious communication by choosing suitable contents. Only if the recipients possess the necessary cognitive requirements and the transversal basic skills, the new knowledge can interact with what they already know.

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