UNIVERSITÀ DEGLI STUDI DI GENOVA

CHEMISTRY IS ALL AROUND NETWORK

518300-LLP-2011-IT-COMENIUS-CNW

Successful Experiences in Primary School Science Education

Laura Ricco, **Maria Maddalena Carnasciali**
Department of Chemistry and Industrial Chemistry, University of Genoa (Italy)
marilena@chimica.unige.it

Abstract

The paper deals with two successful experiences to teach basic chemistry contents at primary school. The first one is an interdisciplinary teaching proposal focused on the chemical process of dissolution and based on the laboratorial approach. It is a long and complex path, composed of several activities, starting from the first year of primary school and concluding at the fifth year. The second activity has a similar objective and the work with children starts in a motivating context: the preparation of pickled olives and fruit in syrup. Both the experiences encourage motivation linking what the teacher proposes to students' experience and daily live and are focused on an active and participatory role of students.

Introduction

During the first two years of work, the project *Chemistry Is All Around Network* [1] allowed to collect and compare several information about teaching of chemistry at school. This information start from primary school, where basics of chemistry are taught within an integrated subject area called Science, and goes on considering lower secondary school, higher secondary school (where, often, chemistry is taught as single subject) and finishes highlighting the critical situation of enrollments to specific degree courses. The analysis of students' feelings towards chemistry, of their performance in relation to this subject and of teachers' experiences is reported in various documents and reports produced by the project and uploaded on the portal. In particular, the national report on students' motivation to study chemistry and the national report on chemistry teacher training are available.

The subject Science, at primary school, promotes a questioning and investigative approach to the environment and prepares children for more detailed studies in later grades. Teaching is usually organized in broad themes, such as states of matter, vegetable world, human body etc. At this level students' feeling are still quite positive, but they develop the first misconceptions that will affect later studies. Moreover, it is worth to be mentioned that pupils' linguistic problems occur from the beginning of primary school: it's when kids realize that some topics are difficult for them that they think they won't be able to understand and decide to use their memory rather 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.

Learning problems become more defined in lower secondary school, where chemistry topics, taught within Science subject, become more complex and face the microscopic level, often in a confused and not adequate way. At this level, some problems start to emerge, the same problems that are more strongly claimed by upper secondary school students and teachers and that make chemistry a subject often rejected:

- the difficulty in the comprehension of the microscopic (abstract) level
- the use of not adequate text books
- the lack of experimental activities
- the insufficient allocated teaching time

Lifelong Learning Programme

This project has been funded with support from the European Union.
This material reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

- the low skills of teachers.

In order to improve the relationship between chemistry and students, the fundamental objective is to enhance the comprehension of contents, by working mainly on teacher training (initial and in-service training) and on the development of good practices and successful experiences that will be diffused and used by the teachers' community.

Regarding teachers' training, the national report, uploaded on the project portal, offers a good description of the Italian situation, including problems, testimonials and reflections.

Regarding good practices, they are numerous and make a classification would be limitative. Good practices frequently make use of laboratory approaches, cooperative learning, problem based learning, ICTs, conceptual maps (built in class or provided by textbooks etc.) and it happens that more approaches are present in the same experience.

Chemistry at primary school

In this context, we will just take two examples of good practices, carried out at primary school where, as mentioned above, foundations for the cognitive development of students are built. At primary school it is important to work on kids' skills of observation and description, on kids' urge to ask questions, to formulate hypotheses, to discuss the latter with classmates or to design experiences to get confirmation of the hypothesis.

All this work must be done strictly limiting to the macroscopic level, because kids do not have the cognitive background necessary to deal with the microscopic level (level of interpretation) of the matter.

Unfortunately textbooks often make this mistake: they concentrate and mix complex contents targeting them to minds unprepared to receive them; the result is that children do not understand, so they memorize or understand in a wrong way, acquiring misconceptions very difficult to correct later.

The experiences that we will describe as examples have in common some basic features, that should be evident in every type of teaching science:

- to encourage motivation linking what the teacher proposes to students' experience and daily lives;
- to focus on an active and participatory role of students who should be protagonists of their own learning process;
- to show that the content the teacher offers and, above all, the goals he/she wants to pursue, extend in all three school grades through further deepening (verticality);
- to have, as teaching model, the laboratorial approach.

On the latter point, it is worth emphasizing that "laboratorial approach" means not only "laboratory activities" (meaning "laboratory" a physical place), but a way of doing school in which student's activity is "experimental". Students participate in an autonomous way to the continuous and systematic activity, during which they use their skills and acquire new ones through various phases of work: they reflect on the issue, answer to written questions, before individually then in group, get involved in collective discussions, perform practical experiences in which they act in first person, and so on.

An interdisciplinary proposal to introduce the concept of solubility and solutions

The first good practice [2] is an interdisciplinary teaching proposal focused on the chemical process of dissolution and based on the laboratorial approach. It is a long and complex path, carried out by Ilaria Rebella and Barbara Mallarino, composed of two steps and several activities, starting from the first year of primary school and concluding at the fifth year. Due to the long lasting of the teaching

This project has been funded with support from the European Union.
This material reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

proposal, its creators and performers published a paper with the aim of providing information about the methodology used and the final results obtained in two classes.
The first step was performed during the first two years of primary school and paid particular attention to the acquisition of lexical and conceptual requirements necessary for further work:
- observation, comparison and classification of transparent, non-transparent, colored, non-colored objects;
- observation, manipulation and considerations of liquid and solid objects;
- observation and description of substances and of their behavior in water.
The goal was to arrive to the construction of a shared definition of "solid substance soluble in water" (i.e. "A solid substance is soluble in water, that is it dissolves in water, when ... no longer visible grains and the liquid is colorless transparent or colored transparent").
The second step was performed during the third, fourth and fifth year. The acquired concepts were recovered and a deepening of the observed aspects was done ("The grains are not seen or are not there more? What can we do to determine this? How much salt can we dissolve in a glass of water? How can I produce a larger amount of solution with the same shade of color?") in order to build the concepts of conservation of mass, saturation and concentration (as ratio between non homogeneous quantities). This goal was reached by linking experiences carried out in different situations (measurements, decimals, fraction and percentage concept, intuitive concept of proportion).
During the fifth year, as conclusive part of the path, a discussion was carried out, aiming to remember what is a solution, as it is recognized, what solutions were prepared in the past and what features were identified.
The discussion was followed by an individual production: "What does it mean that a solution is more concentrated than another?". The answers were shared and discussed.
Finally, teachers proposed a task to verify the learning. The task, showed below, was composed of two parts: the first part (point 1 and 2) concerned individual reflections to make in the classroom, the second part (point 3) was to be performed in the laboratory.
1. How many grams of substance should I use for the following solutions have the same concentration?
15 g of baths salts in 100 mL
……g of bath salts in 1000 mL
2. The solution you are seeing on the desk (250 mL) has a concentration of 3g/100mL of bath salts in water
- How many grams of bath salts were used to prepare it?
- If you had to prepare 1 liter of the same solution (ie a solution with the same concentration of the solution you are seeing on the desk and so with the same color), how many grams of bath salts should you use?
- Explain how you reasoned to find the grams of bath salts that are needed.
3. Prepare yourself an aqueous solution with bath salts. Decide the amount of salt you want to use, then write below how many mL of solution and how many grams of salt you have dissolved:
mL of solution = ………….. mL
bath salts = ……………. g
The solution you have prepared has a bath salts concentration of ……%
Explain how you reasoned.
SUGGESTED PROCEDURE
- Put as much water as you want (without measuring it) in the glass.

- Weigh on the balance the amount of bath salts you intend to put in the glass. Be careful to put an amount that can dissolve completely in the water that you took.
- Mix with the spoon until you get the solution.
- Using the graduated carafe, measure the mL of the solution you obtained.
- Calculate the percentage concentration of bath salts in the solution (note: the concentration is the quantity of substance in g on the amount of solution in mL).

The results were generally satisfactory: even children who had made mistakes, showed to have internalized many of the concepts discussed.

This proposal is very significant as first approach to solubility concept and solutions. The children will improve their logical competences and their skills in self-evaluation, comparing their points of view with their classmates. They will also develop their linguistic and metacognitive abilities. The results obtained have
proved the formative value of the methodology suggested.

Pickled olives and fruit in syrup

This second activity [3] was carried out by Giuseppina Caviglia and Lia Zunino in two classes of primary school (third and fourth year). The theme, the acquisition of the concept of solid substance soluble in water, is about chemistry but the primary goal of the work is to develop first skills necessary for the study of experimental sciences.

The work with children started in a motivating context, the preparation of pickled olives and fruit in syrup. From this, the need to observe, describe, classify, discuss and formulate hypotheses, developed further activities that helped to refine the language and to formulate, at the end of the long process of observation and research, a shared definition of soluble solid substance.

This activity was published as a reliable proposal to introduce basic chemistry concepts and skills needed for further science education. The related publication is a detailed description of the steps of the work and of the results in terms of kids' motivation and cognitive development.

<u>Step1:</u> observation and comparison between two products (pickled olives and fruit in syrup) in order to understand how they were made and to find a way to make them in class.

This step was composed of the following activities:

- *1a.* Comparison of the two products: kids see on the desk a pack of pickled olives and peaches in syrup, and after a discussion guided by the teacher, they perform the following task : "Compare the two products by writing similarities and differences between them. Then write how do you think they were prepared."

The identification and designation of common features leads to consider the possibility that there are similar ways of preparing the two products, even if children do not yet know that they are solutions obtained by dissolving a solid substance in water.

- *1b*. Discussion on the emerged characteristics and on how to prepare the products: naming of the characteristics; comparison between the hypothesis of preparation in order to identify a common recipe; validation of the recipes (consultation of books - cookbooks - or other reliable sources). While explaining how to make the brine, few children indicate quantities: the need to take this into account is explained during the discussion of this phase.
- *1c.* In small groups, realization of the brine and of the syrup: children follow the steps of the common recipe and fill in a worksheet with their observations.
- *1d.* Discussion in the classroom to identify similarities and differences in the preparation steps of the two liquids. The adjective 'soluble' is introduced.

Lifelong Learning Programme

This project has been funded with support from the European Union.
This material reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

- *1e.* Preparation of pickled olives in the classroom: the preparation takes some time (after 40 days the brine has to be changed and after other two months olives are ready to be put in jars) so the teacher can get opportunities to solve computational problems, problems of food durability, problems of packaging etc.
- *1f.* Specification of some terms: in particular the words colorful - colorless - transparent - matt

Step 2 : teachers ask children if all substances are soluble as salt and sugar, and ask them to design experiments that allow to investigate about it. The realization of the experiments, with white and colored substances, raises the question of the "disappearance" of the soluble white substance. The conclusion of the activity is the definition of solid substance soluble in water; the latter becomes the conceptual synthesis, first individual, then shared and collective, of the long path of discovery.
This step was composed of the following activities:
- *2a.* Individual design of an experience to verify if all substances are soluble as salt and sugar. Every child has to write answers to the following questions:
- We will make an experiment to test if all substances dissolve in water like salt and sugar. On the table you see some substances and materials. What actions do we need to perform?
- What do you think it will happen if the substance is soluble?
- What do you think it will happen if the substance is not soluble?
- *2b.* Comparison of the individual projects and development of a unique project and of a worksheet to follow and fill in during the experiments.
- *2c.* Realization of the project, in small groups, using different materials for each group (a soluble and a not soluble substance, for some groups the soluble substance is colored, for others it is not). Fill in of the worksheets and final discussion to compare the results obtained by the different groups with different substances.
- *2d.* Design of an experience to see if the soluble white substance is still present in water after dissolution. Children have the following individual task: "Design an experiment to understand and to prove if a white substance dissolved in water is still present in water or not. You can use the tools available at school or you can bring them from home".
- *2e.* Realization of the experiments and verification of the hypotheses: children see that the soluble white substance does not "disappears" from water, but it becomes "invisible although present, with all its mass".
- *2f.* Getting to the definition of solid substance soluble in water through an individual written work, which is the final assessment of the course. Each kid is asked to write what is a soluble substance and what is a non-soluble substance, thinking about all the work done.

Authors say that the points of strength of the work are the following:
- the teacher has a role of activator of processes;
- discussions allowed students to develop communication and argumentative skills;
- the request of designing, putting the kids in a position to do so autonomously, opens the door to the creativity of everyone, even the weakest;
- The work is developed in terms of observation and description of phenomena and not on their interpretative explanation. This setting is appropriate for a primary school, because an explanation would require the knowledge about the structure of matter that children of this age can not control and understand but only "believe", trusting in the teacher or the textbook.

Conclusions

The two proposals involve contents linked to chemistry and also to mathematic.

This project has been funded with support from the European Union.
This material reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

The study of chemistry can be dealt using the "macroscopic dimension", that allows to describe phenomenological aspects or resorting to the "microscopic dimension" that allows to analyze the composition of substances and provides, on this basis, interpretations of their transformations.
The phenomenological dimension is certainly more accessible and can be used with first cycle students, in order to make them acquiring the academic skills that will be necessary to deal the microscopic dimension.
Some teacher think that, in order to properly acquire chemistry contents, kids should have some transversal abilities and skills such as linguistic skills, logical skills, ability to understand similarities and differences, to describe, to distinguish the description from the explanation, to identify the variables of a phenomenon. Accordingly, they set up students' work basically on the phenomenological dimension of chemistry (4).
Other teachers believe that children potential is enormous and that the microscopic dimension of the discipline can be introduced at primary school. This "theoretical teaching" risks of compromising the development of a conceptual structure suitable to build responses and the development of autonomous behaviors necessary to build skills. In this way, students may only be able to memorize concepts.

Acknowledgements

The authors thank the Lifelong Learning Programme – Comenius Sub Programme, of the European Union for financial assistance.

References

[1] http://www.chemistryisnetwork.eu
[2] Borsese A., Mallarino B., Rebella I., Parrachino I., 2012, *Verso un approccio significativo al sapere scientifico: una proposta interdisciplinare per la scuola primaria,* CnS La Chimica nella Scuola, 4, 141-147
[3] Caviglia G., Zunino L., 2008, *Olive in salamoia e frutta sciroppata*, CnS La Chimica nella Scuola, 4, 100-111
[4] Biavasco et al, 2009, *Per una rivalutazione culturale dell'insegnamento scientifico e della formazione iniziale e in servizio degli insegnanti*, CnS La Chimica nella Scuola, 4, 39-53