

Chemistry Education – the Relevance of Innovative Pedagogical Practices in the Early Years

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Abstract

Consensus exists among researchers and academics that science education, including chemistry education, is fundamental to the development of modern societies. Thus, investment becomes essential, from early years, in the education of informed citizens, prepared with scientific literacy competences and able to pursue an active, participative and responsible citizenship. In this context, school plays a major role and should provide chemistry education for all children. As such, it is necessary that teachers are able to meet this need and ensure the implementation of innovative practices, which, according to current guidelines, should be based in investigative activities of practical and experimental nature with a science-technology-society orientation, whose scientific contents are closely related to certain social phenomena (economics, politics and environment) and that meet the interests of children by helping them to explain and interpret the world around them.

In this paper, we aim to present a review on the current guidelines for education in chemistry in the early years, that is, in pre-school and primary school, by applying a methodology based on practical and experimental work.

1. Introduction

In Portugal, the experimental component of chemistry teaching is undoubtedly valued in the various levels of education, as can be seen in the curriculum guidelines for pre-school education (3-6 years old) and in the curriculum organization and programs for primary school (6-10 years old). Chemistry, in particular, for its multifunctional role in the inter-relationship with other sciences and society, has been a central science to the developments that have marked changes in the needs and human behaviour in the last century. Directly or indirectly, it permeates all aspects of the daily lives of citizens and societies, both in beneficial and determinants aspects of an improved quality of life or in negative aspects affecting health, the welfare of humanity and environmental preservation [1].

Therefore, it is essential that chemistry becomes part of the education of children, because since early they should learn to view the world in a scientific way, they should be encouraged to ask questions about nature and seek answers, collect data, count and measure, make observations, organize data, dialogue with others and reflect on everything they observe. The most important is to get the sense of science and get associated to it, since scientific knowledge can be obtained later [2-4].

Current guidelines in science education privilege the Science-Technology-Society (STS) approach and seek the education of responsible and informed citizens. Since the training of educational agents is a major route to promote science education, it is necessary to develop initiatives to provide training to all practicing teachers on science teaching, with STS-orientation. Additionally, it is imperative that science teachers, and particularly chemistry teachers, reflect on the nature of the fields they teach and on their own perspectives and teaching practices. These considerations become even more critical as current and pressing are the present demands for innovation dictated by international and national contexts of change in the purposes and objectives of science education [1].

Some researchers show that educators point chemistry as the area less focused on the thematic/concepts addressed in the pre-school area of "Knowledge of the World": only 3% [5] and 11% [6].

Thus, initial and in-service training of teachers and educators should address this issue by providing knowledge and methodologies that enable them to develop innovative didactical and pedagogical practices of



chemistry, a relevant scientific domain for the scientific training of children and an essential component of scientific literacy.

2. The relevance of practical/experimental work

As mentioned before, science education has been gaining importance in pre-school and primary school, existing a growing need to implement an education rich in investigative activities, of practical and experimental nature, based on active, participative and participated methodologies, in order to start the construction of scientific contents, develop reasoning, contribute to the understanding of the world, reflect on what might happen if they dare trying to learn and innovate, be autonomous, cooperate with others and fully exercise citizenship.

Practical and experimental activities are considered an instrument of excellence in science learning and should be initiated early [7]. The emphasis on experimental work should be student-centred and, if possible, involve some kind of research [8].

Bóo [9] argues that scientific capabilities and attitudes are best revealed when children engage in hands-on research, where we can see them watching closely, showing curiosity, offering explanations, cooperating with others and behave safely.

In the same line of thought, Caamano [10] and Martins *et al.* [7] consider that in an investigative work of practical nature, four steps are always present: (i) how to define the questions-problems to be studied, (ii) how to conceive the planning of procedures to be adopted, (iii) how to analyse the collected data and establish the conclusions, and (iv) how to set out new issues to explore later, via experiments or not.

2.1. Legal framework

In the context of international recommendations, recent research developments in science education and in teacher training, in particular chemistry, and innovations related to them, advocated for chemistry teaching in Portugal by the movements of reform and curricular reorganization, science education of practical and experimental nature is being emphasized [1].

According to Sá and Carvalho [11], it is in the 60s that a powerful movement for science education in primary schools and pre-schools starts being developed. It is considered that the introduction of different scientific fields can arouse curiosity and desire to learn. Thus, some organizations recommend the promotion of science education from the levels of early childhood education up to the end of basic education, being consensual that scientific literacy should be provided from the early years [12].

Currently, in Portugal, natural sciences are included in pre-school, according to curriculum guidelines from the Ministry of Education [13], in the area "Knowledge of the World", whose main purpose is to arouse children's interest in science, and not exactly the teaching of scientific concepts, being referred that science awareness starts from the interests of children that the educator extends and contextualizes, encouraging curiosity and the desire to learn more. To question the reality, pose problems and seek their solution is the basis of the scientific method. Also, the area of "Knowledge of the World" should allow contact with the attitude and methodology of science and foster in children an experimental and scientific attitude [13].

More recently, Circular No. 17/DSDC/DEPEB/2007 on the management of the curriculum in pre-school education suggests the approach to experimental sciences, even if the collaboration with other teachers is required. The educator, with them, should plan, develop and evaluate the activities, never losing the globalizing view of educational activity in pre-school education.

In primary school, the program of "Environment Study" states that students should deepen their understanding of Nature and Society, leaving to teachers the role of providing them the tools and techniques needed so that they can build their own knowledge in a systematic way [14]. Moreover, "it will be through diverse learning situations involving direct contact with the surrounding environment, conducting small research and real experiences both in school and community as well as through the use of information coming from farther means that students will be gradually apprehending and integrating the meaning of the concepts" [14]. The same document, in the section "Discovering Materials and Objects", states that despite having always present an experimental attitude in the approach to contents, it is primarily intended for this section to develop in students an attitude of continuous experimentation with all that that implies: observation, introduction of changes, assessing effects and results, conclusions.

3. Innovative practices in Chemistry

The child's interaction with the world happens through the manipulation of objects made of materials that are the result of chemical transformations, being some of those reactions carried out in situations that may be more or less close to their direct experiences. Many of the materials that are familiar to us (such as plastic, among others) are the product of these transformations and we contact them in a natural way, with a higher or lower knowledge of the processes that gave rise to them. So, it will be of interest to promote the development of ideas that lead to observations and to a growing understanding [15].

In the chemistry education context, there are many issues that can be developed in pre-school and primary school, using the practical and experimental work. In this respect, as an example, we highlight the following:

- dissolution;
- viscosity of liquids;
- food constituents (biomolecules);
- paper recycling;
- global warming;
- water treatment station;
- mixing colours;
- pH indicators
- ...

Such activities aim to show how chemistry is present in contents often worked in other fields of knowledge, in other situations, contents from scientific and technological areas are included (food, medicines or atmospheric contamination) to illustrate different aspects of the practical application of chemistry with immediate impact on our way of life.

In Portugal, the Ministry of Education (2008-2009) has developed policies to support science education in pre-school and primary school, investing in the production of learning resources such as brochures that include chemical activities. Some of these resources, written in Portuguese, are available online for pre-school and primary school:

- "*Despertar para a Ciência - Actividades dos 3 aos 6*" (Awakening to Science - Activities from 3 to 6) [12].
- "*Coleção Ensino Experimental das Ciências*" (Experimental Science Education Collection) [7].

4. Final remarks

The almost vertiginous change that we witness in scientific and technological terms, allows us to realize the immense instability that the course of times imposes to our contemplation and study in every moment of our lives. Societies are increasingly demanding from the economic, technological, professional and social points of view, where, in many situations, the holistic knowledge prevails. Therefore, it becomes increasingly urgent to educate conscious and participative citizens, able to participate in an informed way in the collective life of the social and cultural group. Experimental work, for the diversity of possible processes and starting points, seems to be able to be considered as an educational pathway promoting spaces of freedom considered necessary for the personal and social development of children and for building their own pathways to knowledge.

Opportunities should be created for teachers to develop practical and experimental activities in the sciences domain, particularly in chemistry, in the contexts of their educational activity, allowing them to set the desired levels of scientific knowledge for their children.

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