

72 - Conceptions of Portuguese Primary School Teachers about Science Education: Their Relevance in Innovative Classroom Activities

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Abstract: Multiple as they may be, all programs designed to promote Scientific Literacy (SL) with an Education for Sustainable Development (ESD) referential and according to Science / Technology / Society (STS) guidelines, include the intention to develop learning and teaching practices that are both innovative and appropriate for contemporary demands. According to several authors, teachers play a decisive role in the quality of education, in the development of favorable attitudes towards the learning of science and in the implementation of curricular reforms. They also agree that the interpretation teachers make of the programs determines their classroom activities

and stems from their own conceptions about science education. Therefore, understanding the conceptions teachers form regarding science education can influence and improve teaching practices and the potential success of educational reforms.

We present Portuguese primary school teachers conceptions about science education (obtained during semi-structured interviews) and in relation to: relevance; ESD; SL; STS guidelines.

Keywords: conceptions about science education; Education for Sustainable Development, innovative practical teaching

INTRODUCTION

The declaration of the Decade of Education for Sustainable Development (2005-2014) gives an important role to education in general, and to science education in particular, in helping solve the situation of planetary emergency humanity currently faces. In Education for Sustainable Development (ESD), Scientific Literacy (SL) was established as one of the contributions that stimulate the understanding of current issues and problems so responsible decisions, justified as they may be in the present, will not compromise the future.

It is not easy to explain how formal teaching and learning of science in primary years of schooling can help develop skills where actions can be justified and do not compromise the future of our democratic society, marked by the prevalence of developments in science and technology, occurring at a fast pace, with implications for personal life, society and the planet.

Achieving these goals requires change in several areas: curriculum; assessment; didactic resources; initial and ongoing training of teachers. With this in mind, we state a view of an SL interpretation transposed into a program, contained in the curriculum, whose design is framed with an ESD referential and Science / Technology / Society (STS) guidelines.

According to several authors (Abell, 2007; Nóvoa, 2007; Osborne, Simon & Collins, 2003; Tobin & McRobbie, 1996, between others) teachers interpret programs according to their conceptions about science education and that interpretation determines their classroom activities. They also contend that, in order to change their practices, teachers should understand their own conceptions about science education and the relationships established between thought and action.

Predisposal to change the methods applied in the classrooms is equally necessary, allowing for a free discussion of problems stemming from the implementation of activities that are not included in their usual repertoire.

Understanding conceptions of the teachers about science education can therefore help us promote mechanisms that will permit an innovative programme implementation in the classrooms.

¹⁷² Acknowledges the financial support of Fundação para a Ciência e a Tecnologia under the SFRH/BD/64866/2009 fellowship.

In Portugal compulsive school includes first Cycle Primary School (1st CEB) for children between 6 and 10 years old: 1st, 2nd, 3rd and 4th school years.

Results of international studies show that Portuguese students have, on average, a performance in the field of scientific literacy significantly below the average of OECD countries (OECD, 2010). Some studies have shown that the practices of science teaching in Portuguese schools are still incomplete, both in working methods, both in time that is allocated to (DGIDC, 2011). Recognizing that the experimental teaching of sciences in the primary years of schooling can contribute decisively to the promotion of SL, the generalization of experimental science teaching in primary education, with appropriate evaluation, constitute a priority objective of educational policy in XVII Constitutional Government.

So, the Portuguese Ministry of Education made “...*experimental science education 2,5 hours a week...*” compulsory and created in conjunction with the Higher Education Institutions and 1st CEB schools, the 1st CEB Teacher Training Program for the experimental teaching of science. This program, nationwide, non-compulsory, involved an in-service training of 63 hours (which included 9 hours classroom monitoring) over an academic year (in Portugal, the school provides the beginning and end of the academic year in September and July respectively, with teaching interruptions at Christmas, Carnival and Easter). The programme also provided the laboratory equipment necessary to conduct the activities listed in the experimental training program to the schools of teachers who voluntarily attended.

The authors of the 1st CEB Teacher Training Program for the experimental teaching of science, which took place over four years (2006-2010), developed and provided educational resources for Teacher Trainers and 1st CEB teachers.

Based on the analysis of the discourse these teachers offer we present conceptions of 1st CEB teachers about science education (obtained during semi-structured interviews) and in relation to: i) its relevance; ii) SL; iii) ESD; iv) STS guidelines.

The selected teachers were involved and devoted to their practices, and their skills were approved by peers.

THEORETICAL BACKGROUND

Several problems connected to the teaching of science can explain the lack of interest for this area and the selection of different academic and professional trajectories, as well as poor student results. Osborne and Dillon (2008) state that the European Union “should invest significantly in research and development in assessment in science education. The aim should be to develop items and methods that assess the skills, knowledge and competencies expected of a scientifically literate citizen” (Osborne & Dillon, 2008, p. 9). The European Commission mentions the unsettling decrease of the interest youth develops towards science, which holds serious repercussions for European development and progress: “the long term capacity for innovation that Europe holds and the quality of its research will also decline. Furthermore, among the population in general, the acquisition of skills that are becoming essential in all walks of life, in a society increasingly dependent on the use of knowledge, is also under increasing threat” (p.2). Attaining such goals calls for change in several domains: curricular, evaluation, resources, initial and ongoing teacher training. We selected the program, as part of the curriculum, because we consider it to be fundamental as a basal structure in the process of teaching and learning. Multiple as they may be, all proposals for a program conception oriented towards the promotion of sustainability include the development of SL and the intention of developing ground-breaking practices for the teaching and learning of sciences addressing current demands, since according to several studies children are predisposed to learn science from an early age (Martins *et al*, 2006).

According to UNESCO guidelines, ESD must detain a high quality, be holistic and oriented by democratic values and principles, aiming for the promotion of a responsible citizenship, aware of the planetary emergency situation we currently face, respecting the limits of our Planet and taking responsibility for all living beings. In that sense, it must consider the complexity of interactions established between the environment, society and economy, all of them essential to sustainability. ESD should be considered at all times in science education: in content selection (multi, trans and inter disciplinary); in context selection for emerging concepts; in classroom strategy/activity selection; in scientific and technological comprehension of problems and their impact in the social, environmental, economic and ethical order; in developing certain skills, aptitudes and values (respect, cooperation, solidarity); in reinforcing democratic values and processes of participation (questioning, debating ideas, managing conflicts, voting, dialoging, reaching consensus).

Different SL conceptualization proposals suggest several implications for the formal teaching and learning of science, concerning the knowledge and the skills that promote an active participation in democratic societies, where the increase of scientific and technological developments, as well as their consequences, requires informed interventions that must not compromise the future (DeBoer, 2000; Praia, 2006). It is not easy to

identify a particular set of knowledge and skills that allows us to proclaim that a certain individual is scientifically literate. Considering the complexity of the concept itself, it is not easy to say “what does holding SL mean?” The SL concept is evolutionary (considering it depends on social and economic contexts in each particular period of time), extremely broad, historically held and still holds several meanings (Martins, 2004).

By defining SL dimension we intend to designate the set of (re)conceptualizations we consider students should have when concluding their primary school years, in order to develop widely varied skills, aptitudes, attitudes and values that will allow them to live and adequately intervene in a democratic society and to adapt themselves to its vertiginous development rhythm, to the implications of this in their lives, in society and in the planet. This attitude should also allow them to continue their studies in science and stimulate them to continue its learning process all throughout their lives.

Despite the debate and controversy concerning what really is evaluated with the PISA tests, their results assume great relevance in our days and the issues they evaluate are consistent with the goals of science programs developed for primary school years and promoting SL. In this study we assume the definition of PISA for SL: “the capacity to use scientific knowledge, to identify questions and to draw evidence - based conclusions in order to understand and help make decisions about the natural world and human interactions with it” (OECD, 2010). The evaluation performed by these PISA tests falls upon: “Knowledge”, “Skills” and “Attitudes”, perceived as: i) “Knowledge – understanding the natural world based in scientific knowledge, including both the knowledge of the natural world and the knowledge concerning science itself”; ii) “Skills – includes identifying scientific questions, scientifically explaining phenomena and drawing conclusions based on data”; iii) “Attitudes – reveal interest in science, support scientific investigation and show motivation to act responsibly when dealing with, for instance, natural resources and the environment.”

We can globally describe the world in which we live by the interconnections established between the broad range of scientific and technological knowledge, mainly developed from the latter half of the 20th century onwards, and all political, economic, social and environmental changes these interconnections imply. STS guidelines for science education reflect a dialog between different scientific fields, namely between natural sciences and social and human sciences, they highlight the social significance of the knowledge set forth by science and technology which, at the same time, provides a better understanding of the natural world and represents an essential instrument for its transformation (Cachapuz et al, 2008). Guiding the education of science with a humanistic, global and less fragmented point of view, and also potentially preparing students to better understand the World and the interconnections between scientific and technological knowledge in society, has become an asset for the teaching and learning of science (Aikenhead, 2009). Studies carried out in different countries in order to understand the impact of STS guidelines in teaching revealed a common attitude improvement from the students towards science, and showed that the comprehension of scientific ideas development is equivalent to the one observed in traditional approaches (Bennett et al, 2006).

A growing body of research suggests that the conceptions teachers form affect their teaching practices, their classroom judgments and classroom management (Lim & Torr, 2007; Thompson, 1992, Van Driel, Bulte, & Verloop, 2008). A better understanding of the educational conceptions held by teachers is therefore essential in order to influence and improve teaching practices and to guarantee the success of educational reforms. Given the importance of an innovative program in the development of this research, we tried to understand conceptions of Portuguese 1st CEB teachers about science education in relation to the importance they perceive in science education and in the structural dimensions of the program: ESD; SL; STS guidelines for science education in early years.

There is no consensual opinion among scholars concerning the definition of teaching conception (Richardson, 1996). The first studies were published in English during the first years of the 20th century (Thompson, 1992) and they applied the same meaning to “conception”, “belief” and “knowledge”. For a long time, despite this conceptual confusion, researchers have tried to clarify their terminological discussion concerning the beliefs of teachers and to define profiles in these beliefs. In this current study we assume the teaching conception that Thompson (1992) defines as: “a wider mental structure that includes beliefs, meanings, concepts, propositions, rules and mental images”, (p.30).

METHODOLOGY

The methodology applied in this empirical study followed a qualitative approach that allowed us to understand conceptions of Portuguese 1st CEB teachers about science education. We chose a semi-structured interview to collect data that allows us to understand: a) the importance they perceive in science education and in the experimental science teaching component; b) how they believe science education can contribute to EDS; c) what subjects they relate to the EDS concept and how are those subjects approached in the

classroom; d) how they perceive SL, how significant they believe developing SL skills is and what strategies they apply in the classroom in order to achieve it; e) what SL skills they consider a student should have developed when concluding primary school, considering EDS; f) how they perceive STS guidelines for science education and how they are applied in the classroom.

We interviewed 19 experienced 1st CEB teachers, whose value is recognized by their peers (as involved and devoted to their practices), teaching in Portugal during 2010/11.

The results were obtained using the content analysis of interviews. According to Bardin (1997) it intends to “overcome uncertainties” and “enrich its reading” (p.29).

RESULTS

We now present the obtained results, according to each item approached during the interview.

Importance perceived in science education and its experimental component

All interviewed teachers believe it is very important to teach science in primary school years (from 6 years of age), pointing out some of the following reasons (in order of frequency): it is interesting for the children; it satisfies the curiosity of children; it is ever-present in our current lives; it helps children to understand/interpret daily phenomena (or what they see on the TV and in the Internet); it teaches children to think; it enhances interdisciplinarity.

All teachers mentioned that the reason why after September 2006, “...*experimental science education 2,5 hours a week...*” becomes compulsory, was the need to fight a general tendency to perform very few “experiments”, and only in the end of the school-year (as proposed in school manuals).

Some of the experimental activities performed prior to 2006 and mentioned by the teachers included seed germination and floating solids in liquid media. The most frequently referred methods for those “experiments” were: i) concerning germination: wrapping the seed in moist cotton, placing it in a glass container, exposed to light, and “watering” and “observing” it; ii) concerning floating: several objects were placed in a bowl of water and students “had to say if they floated or not”. Less frequently, they also mentioned changes in physical states (interpreting window “misting” during winter) and solutions (students verified that sugar and salt “disappear” when mixed with water).

Although they recognize the interest of experimental activities for their students, allowing them to develop transversal skills related to reading, writing, communicating and calculating (and despite being compulsory) they admitted they did not always perform 2,5 hours of experimental activities per week, stating: it is more important to teach them how to write, read and calculate; the current program does not offer guidelines for experimental activities that fulfill the established educational component; they do not feel sufficiently prepared to perform experimental activities; there is no equipment in schools.

Teachers attaining the 1st CEB Teacher Training Program for the experimental teaching of science reported: they feel better prepared to perform experimental activities with their students; they perform more experimental activities; the importance of the laboratorial equipment supplied to the school by this program.

Science education contributes to EDS

All teachers believe that science education can contribute to EDS, as long as “children are alerted to the importance of adopting behaviors that will not compromise the future of our Planet”. According to most of them, developing suitable attitudes and behaviors from an early age allows them to grow into “responsible adults”.

EDS related subjects and how they are taught in the classroom

The subjects most frequently identified by teachers are: pollution; water and energy scarcity; biodiversity loss (“taking care of animals and plants” to avoid their extinction); and resource finitude. Less frequently they also mentioned local asymmetries (concerning in particular hunger and poverty) and respect for “different” children.

They all think these subjects should be taught in the classroom for every 1st CEB years, and they mention a teacher-moderated debate as the privileged strategy. Involving children in research and field trips, as well as inviting specialists to classroom debates, were also mentioned.

Generally speaking, subjects are brought to the table by students themselves (because they heard about it on the TV news or read about in the Internet), or they result from reading texts proposed by the teacher in Portuguese language classes. However, the celebration of water, alimentation and environment days and the international forest protection year are considered privileged moments to teach subjects related to them, and they are implemented in the *Project Area*.

SL conceptualization, the importance perceived in developing SL skills and preferred classroom strategies

Most teachers think that an SL holder is someone with a “great scientific and technological knowledge”. This knowledge was less frequently associated with a responsible citizenship and with the implications of our actions for our Planet, ourselves and others.

All teachers believe that formal education should include the development of SL skills during all 1st CEB school years, and teacher-moderated classroom debates are considered the most promising strategy for any school year. Concerning 3rd and 4th grade children they also include: researching and preparing a presentation for the class; “experimenting”; making flyers and posters. Some of the strategies these teachers mentioned for the development of SL skills include: involving students in the separation of trash for recycling in school (and asking them to do the same at home), giving them guidelines to save water and electric energy, and studying behavioral changes in them through dialogue. Choosing an adequate diet, in an individual health perspective, and involving children in solidarity campaigns (collecting toys and clothes for children in need) were also mentioned. They all believe children play a significant role in influencing their parents to adopt the same behaviors.

All teachers believe that the benefits of scientific and technological development outweigh the setbacks. They most frequently pointed out developments that helped solving environmental issues and led to health and lifestyle improvements as positive aspects. The majority of the participants believe that science and technology only can help us solve the problems we currently face. All of them think it is important to debate both the advantages and disadvantages of such developments.

All teachers blamed the Human Being for the problems we currently face. They most frequently referred to the bad use we make of scientific and technological developments, based on a “poor knowledge or a lack of civism”. They all consider the importance of debating positive and negative aspects of scientific and technological developments with their students.

SL skills that a student should have developed when concluding primary school and according to an EDS referential

Almost all teachers contended that students should “be able to make decisions in order to preserve the environment”.

STS guidelines for science education and classroom experiments

Only one teacher revealed that his activities “involve science-society-technology interaction and intend to form responsible, critic and active citizens”. All other teachers had no knowledge of the STS guidelines for science education, or they knew they existed but did not know what they were exactly.

CONCLUSIONS

The teachers who participated in this empirical study believe that science education is very important during primary school years. Notwithstanding, teaching the Portuguese language and Mathematics is considered more important.

Generally speaking, teachers assign some EDS related subjects to their students and reveal some concern with the development of SL skills. However, no intentional and systematic connections are established between those subjects, resulting in occasional and fragmented approaches. The conceptions these teachers hold of EDS and SL are practical directions.

Concerning EDS, all subjects considered the most relevant by these teachers are essentially environmental (general pollution, water and energy scarcity, and resource finitude). Social and economic components are barely mentioned, and no connections whatsoever are established between all these subjects. There is also no mention of demographic growth and its concomitant demographic pressure or current consumerism levels and respective impacts. Respecting and protecting biodiversity (although these terms are not applied) are assigned to the students so they can learn how to accept “different” children and “take care of animals and plants”, respectively.

Subjects that deal with the impact of science and technology are also assigned to students, frequently related to school and domestic environments and to the comfort they bring to our daily lives. General pollution and environmental degradation are often mentioned as its setbacks. They do not mention any influence of science and technology in the increase or decrease of asymmetries and they also do not highlight their importance in identifying and predicting problems.

In short, we can conclude that teachers who participated in this empirical study perceive little value in science education, they recognize scientific and technological knowledge for its intrinsic value but they do not establish any intentional connections between that conceptual body and the development of SL skills.

Similarly, ESD constitutes an occasional and unintentional reference, and teachers do not establish any connections between ESD and scientific and technological knowledge (re)conceptualizations or the development of SL skills. Almost every subject assigned to students and considered relevant relates to that region, to the country and to the environment.

These teachers apply teaching and learning methodologies that do not follow STS guidelines for science education.

The conceptions we found among the teachers who participated in this empirical study, concerning the dimensions of the analysis that we previously defined (the importance they give to science education, ESD, SL and STS guidelines for science education) drew back the emergence of innovative classroom activities.

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