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Problem-Based Learning And Nature Of Science: A Study With Science Teachers

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Abstract

Problem-Based Learning, a methodology that builds on problems to develop students' new knowledge, can also be useful in helping students to learn Nature of Science. Prospective science teachers' conceptions regarding Nature of Science and its teaching through Problem-Based Learning were analyzed by applying a semi-structured interview. Nine respondents recognized that this methodology promote research activities and contribute to the learning of some aspects of scientific inquiry. Moreover, they specifically considered that Problem-Based Learning may foster the understanding of the tentative nature of scientific knowledge and of the role of creativity implicit in scientific endeavor. Authors consider that more attention should be given to the contemporary Nature of Science views and to its consistent teaching through this methodology.

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1. Introduction

Science curricula includes the understanding of scientific contents, laws, theories, methods and procedures used by scientists, as well as the comprehension of how scientists develop and use scientific knowledge, and how they collect and interpret scientific data (Ryder, Leach, & Driver, 1999). All of these aspects are related to the learning of Nature of Science (NOS), which is crucial to the development of students' scientific literacy. To help students from

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middle and secondary schools to understand NOS aspects (Abd-El-Khalick et al., 2004), and to develop their scientific literacy, it is necessary that science teachers hold adequate conceptions of NOS (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). This NOS knowledge is fundamental in order to teach NOS aspects (Akerson, Buzzelli & Donnelly, 2009) through methodologies that promote activities in which students develop knowledge and the understanding of scientific ideas, as well as catch on how scientists study the natural world. One of these methodologies is Problem Based Learning (PBL) (Bache & Hayton, 2012).

2. Framework

2.1. Nature of Science

The concept of NOS is related to the epistemology of science, and considers the values and beliefs inherent to the development of scientific knowledge (Lederman, 1992). As such, NOS assumes an important role in science lessons since it helps students in the process of developing scientific literacy (Akerson, Buzzelli, & Donnelly, 2009). NOS conceptions have changed in its systematic thinking about its nature and endeavour throughout the development of science. Lederman, Abd-El-Khalick, Bell and Schwartz (2002) consider that scientific knowledge is tentative and empirical, it is partly the product of human inference and it is socially and culturally embedded. These authors also maintained that observations are constrained by our perceptual apparatus, that the making of hypotheses involves imagination and creativity, and that both of them are theory-laden. First of all, in order to develop correct NOS conceptions, students should understand that scientists do not have direct access to most of the natural phenomena and are unable to construct reality. Instead, they work with representations of nature which are influenced by their own perceptual apparatus and interpreted from their own theoretical frameworks (Lederman, 2007; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). Moreover, since science is empirical, the development of scientific knowledge involves the observation of nature, which is influenced by human imagination and creativity (Lederman, 2007). It is also important to clarify that research is always motivated and guided by questions or problems that derive from certain theoretical perspectives and cause scientists to observe, to compare, to speculate, to hypothesize and to formulate explanations, but there is no exclusive sequence for obtaining valid solutions or answers. Methodology depends on the purpose and the aims of the study, and can be variable (Lederman, Abd-El-Khalick, Bell**,** & Schwartz, 2002). Very often students think that science is completely objective and that scientists formulate theories that result from an objective data analysis. But it is important to clarify that science is practiced in a cultural context and *its practitioners are the product of that culture* (Lederman, Abd-El-Khalick, Bell**,** & Schwartz, 2002, p. 501). As such, science is developed through individual questioning and debate with other members of the community (Ryder, Leach, & Driver, 1999) and, it is affected by many elements, such as society, politics, socioeconomic factors, philosophy and religion (Lederman, 2007). Taking this latter aspect into consideration it is easy to understand that scientific claims change as a result of new evidence, but also through the development of social beliefs and way of thinking. New evidences are reinterpreted according to new theoretical assumptions, cultural and social changes or shifts in the directions of established research programs (Lederman, Abd-El-Khalick, Bell**,** & Schwartz, 2002). Although these NOS aspects should be taught in science lessons, some research studies show that the relationship between teachers' NOS conceptions and their classroom practice is complex. Indeed, several variables interfere with the inclusion and practice of NOS in classrooms, such as classroom management, concerns for student abilities and motivation, institutional constraints, teaching experience and discomfort with the understanding of NOS (Abd-el-khalick & Lederman, 2000). Despite all of these constraints, there are many different methodologies to improve NOS teaching in science classrooms. One of these is PBL, which is an inquiry based learning approach.

2.2. Problem Based Learning as an Inquiry strategy

PBL is a teaching methodology which uses problems as the starting point for the development of students' new knowledge (Chin & Chia, 2004; Lambros, 2004). Students learn while searching for solutions to those problems, and thus learning is purposeful and self-motivating. Students are actively involved and learn within the context in which knowledge is to be used (Chin & Chia, 2004). The role of the teacher is to facilitate this process of problem-

solving (Bache & Hayton, 2012; Chin & Chia, 2004, Vasconcelos, 2012), for example, by *monitoring discussion and intervening when appropriate, asking questions that probe accuracy, relevance, and depth of information and analyses, raising new issues for consideration, and fostering students participation* (Allen, Donham, & Bernhardt, 2011, p. 23). This methodology is included in the Inquiry-Based Teaching perspective, which constitutes a dynamic process, in which learning is a process of continuous thinking that involves flexibility and judgment. Moreover, inquiry processes promote the development of critical and reflective thinking about the process itself, as well as involve emotional aspects such as curiosity (Sadeh & Zion, 2009). According to an Inquiry approach, during science lessons students develop scientific knowledge and epistemological understandings about NOS (Lederman, 2007), as well as relevant inquiry skills, such as identifying problems, formulating research questions, designing and conducting research, communicating, and arguing in favor of hypotheses, models, and explanations (Abd-El-Khalick et al., 2004; Sadeh & Zion, 2009). Kim, Tan and Talaue (2013), argued that science teaching is not only about the students' acquisition of content knowledge, but it is also related to the development of skills and *modus operandi* that help students in their everyday lives problem-solving and decision-making processes. An inquiry approach establishes that students should be provided with opportunities to gather evidences, to decide upon their value, and to craft coherent scientific explanations based on those evidences (Kim, Tan, & Talaue, 2013). For all of the above, PBL is considered to be very important in science teaching since it may enhance the emotional domain of the students' learning process, improve their performance on complex tasks, and foster a better knowledge retention (Allen, Donham, & Bernhardt, 2011). As such, Inquiry was noted by science educators as a methodology that fosters the development of students' scientific literacy. Accordingly, it has become the central part of the science curriculum for the twenty-first century, in many countries (Abd-El-Khalick et al., 2004). But its successful implementation depends on the teachers' scaffolding of students' active learning and knowledge construction (Allen, Donham, & Bernhardt, 2011).

3. Methodology

Considering the purpose of the study, we applied semi-structured interviews to 17 prospective science teachers that teach Biology and Geology in middle and secondary schools this year (2013/14). Interviews were focused on two main questions: (i) what teaching perspective is conveyed through PBL? and (ii) which NOS aspects can be developed through PBL? Answers were audio taped so as to guarantee a better and more reliable data transcription. After the transcription, two team researchers with experience in qualitative methods applied content analysis. The sample integrated 12 female and 5 male students, all of them studying for master degrees in biology and geology teaching, in a Northern Portuguese public University.

4. Results

After the content analysis of the two questions and considering the objectives of the study, the following results were obtained.

Table 1. Students' answers to Q1: what teaching perspective is conveyed through PBL? (n=17)

Categories of answers	Frequency	(%)
Inquiry Based Learning	11	64.7
Socioconstrutivism	3	17.6
Problem Based Learning	1	5.9
Conceptual Change	1	5.9
I don't know	1	5.9

The analysis of the question Q1 (table 1) reveals some interviewees' misconceptions. Nonetheless, the majority of students (64.7%) recognize that PBL is an Inquiry-Based approach.

Table 2. Students' answers to Q2: which NOS aspects can be developed through PBL? (n=17)

Categories of answers	Frequency	(%)
Post Positivist View	6	35.2
Externalist View	6	35.2
Tentative Nature of Science	5	29.4
Creativity and Imagination	2	11.8
Rationalist View	1	5.9
Internalist View	1	5.9
Science is Discontinuous	1	5.9
Science is Continuous	1	5.9
Generalist/Regionalist View	1	5.9
Critical Spirit	1	5.9
Science is fallible	1	5.9
I don't know	2	11.8

In question Q2, ten prospective teachers referred more than one aspect of NOS. As presented in table 2, six of them (35.2%) consider that PBL allows the development of a post positivist and externalist view of science and five students (29.4%) recognize that PBL helps to understand the tentative nature of science. Moreover, two prospective teachers also refer that creativity and imagination may be developed through a PBL approach. Finally, the simultaneous data analysis of the two questions also show that nine students (52.9%) acknowledged PBL as an inquiry approach that should promote research activities mirroring scientists' work, and recognized that it helps to learn NOS aspects. As an example, we can focus on some answers:

Post-positivist view because they have a reasoning behind it all, not enough to solve the problem presented to them based solely on experience, they will evaluate several things (...) (E10)

An externalist view in the sense that the history of science is necessary for students to understand how science is built (...). They will learn and simulate what happened (...), so it is important that they understand that science is developed by men and is not infallible, and it is essential for students to be aware of its limitations and what we can achieve with science. (E11)

Students can learn the tentative nature of scientific knowledge, and they can realize that what is learned now may not occur in the near future because scientist can find new facts to improve what is known. (E13)

5. Conclusions

With this research we may conclude that Portuguese prospective science teachers acknowledge the importance of PBL as an inquiry approach that helps teachers to explain some NOS aspects. They recognize that PBL may lead students to understand the impact of social and cultural aspects on the development of scientific knowledge, which influences its tentative nature, but also the importance of creativity and imagination in the construction of scientific knowledge. However, there are some NOS aspects that were not mentioned by prospective science teachers thereby signaling that more attention should be given to contemporary NOS views and to its consistent application in science lessons.

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