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Science as a cultural activity: comparative study of Brazilian and Portuguese teachers' conceptions about science

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Abstract

This is a comparative study on Brazilian and Portuguese science teachers' conceptions about science and cultural diversity awareness. Interviews before and after the TE-CD course revealed differences between teachers of both countries, which may be associated to their previous teacher training and social context. This preliminary study showed that further research in both countries is of paramount importance in order to elucidate in more detail the differences not only between the science teachers' conceptions about science but also between their teacher training. This can contribute to improve science teacher training curriculum in both countries, with special reference to cultural diversity.

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1. Introduction

In the last two decades, it has been increasingly more common the view that science teachers must construct appropriate conceptions about the nature of science (NoS), since only in this way they will be able to convey appropriate conceptions about science they teach (Ameh & Gunstoner, 1985; Rutledge & Warden, 2000; Gil-Pérez et al., 2001; Capps & Crawford, 2013). Appropriate conceptions about the NoS mean those related to the understanding of science as a cultural activity of scientists in particular periods, comprising a set of inherent values and assumptions in the development of the scientific knowledge (Lederman, 1992).

However, most teachers and future teachers have inadequate conceptions about the nature of science (Gil Pérez et al., 2001). One must highlight that in some cases the concepts are missing or made incomprehensible when teachers

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are unable to express any meaning or fail to conceptualize the scientific concept clearly. Gil-Pérez et al (2001) have identified among science teachers the following seven views about science: 1 - empirical-inductive and non-theoretical (observation and experimentation assumed as neutral, i.e. not influenced by preconceived ideas); 2 - Rigid (algorithmic, exact, infallible, etc.). 3 – non-problematic and non-historical (hence dogmatic and closed); 4 - Exclusively analytical (highlighting the studies demarcation and specialization, their limited and simplifying character, and so forgetting efforts of unification and construction of coherent bodies of knowledge); 5 - Cumulative linear growth (scientific findings as the result of a purely cumulative linear growth, which ignores paradigm crises and major reconstructions); 6 - individualistic and elitist (scientific knowledge is the result of the work of isolated geniuses, ignoring the role of collective and cooperative work with exchanges within and between teams) and 7 - decontextualized (socially neutral).

In science teacher training for cultural diversity, a proper understanding of the nature of science should be stressed in order to allow the teacher to understand the characteristics that are intrinsic to science, as one among the numerous existing cultures. This will contribute to the demarcation of scientific knowledge (school) in relation to other cultural knowledge that can be present in the classroom (Cobern & Loving, 2001). In addition to the didactic transposition of scientific knowledge in the context of the classroom (Chevallard, 1985), the values and social practices should be taken into account (Clément, 2006; Carvalho, 2009). In this sense, the intercultural dialogue between the thought science and other systems of knowledge becomes pertinent. In such dialogues the relationships between the science culture (which is transmitted by the teachers) and the students' cultures should be established in order to make students understand the origin and the domains of validity of various systems of knowledge and systems of values. When this happens, students may develop their visions of the nature enhanced with scientific ideas and apply the acquired knowledge (either from scientific culture or from their own cultures) in contexts and practical situations (El-Hani & Mortimer, 2007).

Considering that a great number of science teachers have inadequate conceptions about the nature of science (Gil-Pérez et al., 2001), it is necessary that they develop epistemological reflections, by analyzing the NoS of their teaching and providing them of a broader view of knowledge as object of teaching, the curriculum and the methodologies of teaching (Apostolou & Koulaidis, 2010). According to Carvalho (2002), teacher's reflections about the NoS can provide a more adequate understanding of what science is about, how scientists operate as a social group in particular periods, etc. In this way, a more appropriate science teaching is possible so that students can understand better the nature of science they are learning about. Included in this scientific view of knowledge, some relevance has also been given to the cultural knowledge, which can involve the complex set of relationships of plants and animals with the past and present human societies, in the so called field of Ethnobiology (Berlin, 1992).

The NoS can be better understood by teachers if the contribution of history and philosophy of science is taken into account (Clough, 2012), assisting in the epistemology of science, i.e. helping the "*understanding of the structure of science and the space it occupies in the intellectual system*" (Matthews, 1995, p. 165).

In this paper, a comparative study of Brazilians and Portuguese science teachers' conceptions about science are presented and discussed in view of the influence on science teaching course addressing cultural diversity: "*Contributions of Ethnobiology, History and Philosophy of Science for Teacher Education addressing Cultural Diversity*" (in short: TE-CD). The purpose of this course was to create opportunities for teachers to reflect about research and understanding of the cultural knowledge that certain societies and cultures have towards nature and its elements. Data was obtained before and after teachers' training on history and philosophy of science, with particular focus on the consequence of the cultural knowledge demarcation to intercultural dialogue in science education. Addressing cultural diversity in science teaching means to investigate, understand and consider students' cultural diversity in order to promote intercultural dialogue in the classroom. The research questions are the following: (i) how do Brazilian and Portuguese science teachers conceive the science they teach? (ii) What are the similarities and/or differences between Brazilian and Portuguese teachers' conceptions about science? (iii) What are the influences of Brazilian and Portuguese teachers' science conceptions on teaching science addressing cultural diversity in both countries? Stated in other words, what intercultural dialogue can be established between the scientific contents and cultural knowledge of student-teachers?

2. Methodology

This qualitative research was carried out with semi-structured interviews (Bogdan & Biklen, 1994), in a multiple-case study (Godoy, 1995; Duarte, 2008).

2.1. Participants

The participants in the Brazilian sample were 9 Biology teachers of public middle school (teaching 15-17 years old students) of different towns in the Eastern Region of the Bahia State. The age of these female teachers was between 28 and 41 years old.

Six Biology teachers composed the Portuguese sample (3 female and 3 male) of public kindergarten and primary school (0 to 12 years old children) of the Northern Region of Portugal. The age of these female teachers was between 26 and 44 years old.

Between the two data collection moments (before and after the TE-CD) dropouts in both samples occurred, being at the end 6 Brazilian teachers and 4 Portuguese ones.

Qualitative research requires consideration of ethical issues, particularly due to the proximity between the researcher and participants (Martins, 2004). In Brazil, the standards of the Resolution 196/1996 on research involving humans of the National Health Council of Brazil were taken into account. Therefore, for this study, a Statement of Consent from each participant was obtained. This term included the following items: explanation about the research, including the freedom to refuse to participate or withdraw his/her consent at any stage of the research; explanation about the social relevance of this research; information about the methodology of the study; assurance that the research would cause no costs for the participants; declaration on confidentiality, ensuring the privacy of the identity of the subjects; respect for cultural values and feelings expressed by subjects, among other aspects. Similar ethical issues were considered in Portugal.

2.2. Teaching module on Ethnobiology

The TE-CD courses on “*Contributions of Ethnobiology, History and Philosophy of Science for Teacher Education addressing Cultural Diversity*” were carried out by the first author in subsequent periods, the first in Brazil and the second in Portugal. In Brazil it had a total workload of 132 hours and was held in the State University of Feira de Santana (UEFS), in the city of Feira de Santana, Bahia, Brazil. In Portugal, the TE-CD course had a total workload of 130 hours and was held at the Institute of Education, University of Minho (UMinho), in the city of Braga, Northern Region of Portugal.

The overall aim of this TE-CD course addressing cultural diversity was to contribute to raising science teachers’ awareness of cultural diversity in classroom and how to deal with it in science education. In other words, it was intended to promote the cultural dialogue of science with the students’ cultural knowledge. The course had interconnected theoretical and practical approaches and consisted of the following strategies: dialogic presentation; reading and discussion of papers; and preparation and presentation of educational resources in order to carry out intercultural dialogue in science education.

The following themes were discussed with both Brazilian and Portuguese samples: (i) “Ethnobiology and its contributions to intercultural dialogue in science education”; (ii) “Science teachers’ training for cultural diversity”; (iii) “Contributions of the history and philosophy of science for the demarcation of cultural knowledge in Science Education”. A further theme (iv) was specific for the Brazilian teachers “Agricultural pest, a possible content for intercultural dialogue in Science Education” and for the Portuguese teachers “Health, a possible theme for intercultural dialogue in science education”.

2.3. Data collection and analysis

Semi-structured interviews were applied to the Brazilian and Portuguese participants. They were recorded and transcribed. The average time was 30 minutes for interviews prior to the TE-CD course and 24 minutes for interviews after the course.

A sequence of codes was given to each interviewed teacher, in order to ensure her/his privacy, as follows: From Brazil: BT-1 (Brazilian Teacher 1), BT-2 (Brazilian Teacher 2), and so on; From Portugal: PT-1 (Portuguese Teacher 1), PT-2 (Portuguese Teacher 2), and so on.

In order to facilitate comparisons, two categories were created *a priori*: (i) before the TE-CD course and (ii) after the TE-CD course. In each of these categories, the answers given by the Brazilian and Portuguese teachers were arranged side by side in tables (see Tables 1 and 2 in “Results and Discussion”).

The analyses was carried out on these two categories by interpreting and comparing the Brazilian and Portuguese answers and discussing them based on the literature in science education and teachers training for cultural diversity. The objective was to identify similarities and/or differences between the conceptions of the participating teachers before and after the TE-CD course.

3. Results and Discussion

Of the numerous interview questions, for this paper only the following ones were analyzed and discussed:

“In your idea what is science? For example: Evolutionism or Intelligent Design? Astronomy or Astrology?”

3.1. Category 1: Before the TE-CD course

The most relevant speeches of Brazilian and Portuguese teachers answering to the question before attending the course on "Contributions of Ethnobiology, History and Philosophy of Science for Teacher Education addressing Cultural Diversity" are shown on Table 1.

Table 1. Speeches of Brazilian and Portuguese teachers before the TE-CD course

Brazilian Teachers	Portuguese Teachers
Science is a part of our culture that attempts to explain the phenomena in nature ... which tries to investigate solutions to the problems we have and try to know the environment where we live... (BT-1).	Science... to know, isn't it? Knowledge, isn't it? It is... linked to different areas of knowledge... the science is related to the method which can be proved... and also cannot be proved, isn't it? (PT-1).
Science ... is such a big field ... is a range of related knowledge... I don't know, I got lost now ... you shook me ... It's such an abstract thing to say, isn't it? (BT-3).	Science ... has to do a bit with scientific methods ... I don't know ... there are themes ... There is only one science ... science ... There are various issues ... I do not know (PT-2).
It [science] is knowledge about something ... related to something ... it's knowledge... scientific is all that needs to be investigated ... scientifically proven, but I believe they also bring is a... is science, is a popular knowledge, or traditional... (BT-4).	... To say what it is, it's complicated! Science tries... to show by a method, and a goal, to explain the phenomena of nature ... of our day to day, through the scientific method ... there is a method which is the scientific method ... (PT-3)
In the way to study ... there are several sciences ... I guess it is the question of... disclosure ... and the methodology of the study... the academic, he works on steps ... not only disclosure. I think this thing is the method ... (BT-5).	Science ... is what is linked to research ... but it's hard to speak ... it isn't only that science, the one we are used in the laboratory but it is science ... it has to do with methodology... it's theoretically supported... (PT-4).
... it would be linked... to the method, an observation, experimentation and an outcome and a discussion of these results, including a likely ... then a repetition of this ... (BT-8).	Science to me is ... science is the study that has the experience, isn't it? Has an underlying theory experimentation ... (PT-5).

Among the answers given by the Brazilian teachers the conception of **science as culture** emerged. For example, BT-1 said (Table 1):

“Science is a part of our culture that attempts to explain the phenomena in nature”. (BT-1).

In contrast, this concept of science as culture was not revealed in the speech of the Portuguese teachers before the TE-CD course.

The conception of science as culture is very close to that hold by most researchers in the science education literature. For example, Lederman (2006) has mentioned that science is one among the various cultures that seeks to describe natural phenomena and, according to Gil-Pérez et al (2001), one must understand the social nature of the scientific development, influenced by the problems and circumstances of the historical moment, and also consider that the scientists' actions have a strong influence on the physical and social environment in which they operate.

Another conception disclosed in the statements of Brazilian and Portuguese teachers was **science as any study or knowledge about something**, as the BT-4 and PT-1 (Table 1) said:

“It [science] is knowledge about something ... related to something ... it's knowledge”. (BT-4).

“Science... to know, isn't it? Knowledge, isn't it? It is... linked to different areas of knowledge”. (PT-1).

This conception of science as any study or knowledge about something is too general, too wide, which can result of the lack of historical-epistemological studies during the teachers' training in both countries. Delizoicov et al. (2002) as emphasised that a fragmented degree in teaching modules that focuses on specific content learning and lacking discussion about science epistemology and its historic role, ends by leading the future teachers not understanding the nature of science. Therefore, teachers are unable to make boundaries between science and other systems of knowledge, as was evident in the speech of PT-4, who included all forms of knowledge as science:

“Science ... is what is linked to research ... but it's hard to speak ... it isn't only that science, the one we are used in the laboratory but it is science ... it has to do with methodology... it's theoretically supported”. (PT-4).

The BT-4 speech also shows to be very influenced by the specific asked questions “For you what is science? For example: Evolutionism or Intelligent Design? Astronomy or Astrology?”:

“Scientific is all that needs to be investigated ... scientifically proven, but I believe they also bring is a... is science, is a popular knowledge, or traditional”. (BT-4).

It is possible that the teachers have interpreted these questions as a collection of choices between the two examples given, as if they were closed questions. So, they struggled to formulate clearly a response to the meaning of science.

In addition, from the BT-4 answer emerges the science conception that traditional knowledge is a kind of science that differs from the one practiced by the scientific community. Indeed, in the view of El-Hani & Bandeira (2008) traditional knowledge is not constructions of science, but rather legitimate constructions of traditional communities and, therefore, valid according to epistemic criteria that are defined in their own cultural patterns. Thus, the differentiation between traditional and scientific knowledge is the entire set of characteristics that are peculiar to each of these forms of knowledge (Bandeira, 2001).

The teachers’ reference that science is knowledge can be explained by the etymological meaning of the term “science” from the Latin “*scientia*”, meaning knowledge. However, how the scientific processes are carried out today are so much specific that the definition of science just as knowledge is too wide. Therefore science must be viewed as one of the several forms of knowledge, with specific modes of knowledge production (El-Hani & Bandeira, 2008). In contrast, Cobern & Loving (2001) admit that all forms of knowledge can be considered as a science, but this view does not contribute to intercultural communication. It rather contributes to the failure to recognize cultural differences in classrooms, in that instead of recognizing the variety of knowledge existing among students, it embraces all different kinds of knowledge in a general form of science. One consequence is that students will not be able to apply their different knowledge in various contexts and situations in which such knowledge may be requested.

The demarcation between science and other forms of knowledge should be preserved in science education addressing cultural diversity. In this way, students can be aware of the structure and scope of the different ways of knowing, and so science education will be valuing cultural diversity by its own criteria of validity and legitimacy (El-Hani & Mortimer, 2007).

Brazilian and Portuguese teachers showed responses that suggest insights that **science has a specific method** and that scientific knowledge is derived from observation and experiences and observations about the natural world. Examples of these responses can be found in the quotations shown on Table 1 of Brazilian teachers BT-5, BT-8 as well as Portuguese teachers PT-1, PT-3, PT-4 and PT-5.

However, as discussed by Gil-Pérez et al. (2001), one must reject the idea that science works with a single method, since the history of the construction of scientific knowledge is marked by a methodological pluralism. This author further refuses the only view of “*an empiricism which sees knowledge as a result of inductive inference from raw data*” (Gil-Pérez et al., 2001, p. 136). After all, scientific data cannot be obtained nor interpreted on the basis of observations in trials only, i.e. data obtained in scientific research should always be interpreted in light of its theoretical framework in order to make sense.

Although accepting the argument that there is no single method for doing science, Irzik & Nola (2011) point out that the scientific method cannot be regarded as less controversial about the nature of science, because there are methodologies and methodological rules that guide the scientific practice in general. Alternatively, these authors propose a characterization of science based on “family resemblance”, being necessary to consider that there is a set of characteristics that are specific to some sciences, but not to others, thus forming a set of family resemblance. In other words, there are differences between the specific sciences, but also similarities between one another (Irzik & Nola, 2011).

Finally, before the TE-CD some teachers, BT-3 and PT-2 (Table 1), were not able to give any understandable explanation of what science is about.

3.2. Category 2: After the TE-CD course

The most relevant speeches of Brazilian and Portuguese teachers answering to the question after attending the course on “Contributions of Ethnobiology, History and Philosophy of Science for Teacher Education addressing Cultural Diversity” are shown on Table 2.

Table 2. Speeches of Brazilian and Portuguese teachers after the TE-CD course.

Brazilian Teachers	Portuguese Teachers
To define [science] is still very difficult for me ... There is Western science, which is the one thing that came out of colonialism, which in turn is related to the seventeenth century, the steps, the method ... is the path that will allow understanding the natural world ... I say it isn't, but sometimes I wonder medicine has been developing studies that show how a patient's faith has helped him improve ... science does not work with the supernatural world but when I see certain things that was not the domain of science being researched, so I'm wondering... (BT-5).	Science is a proved experimental method, through a way which is usually a journal ... and that is recognized by a group as such. Science is one culture, because there are other cultures (PT-1).
There isn't a unique concept [of science] ... it has to do with the natural ... in fact it isn't immutable ... to be scientific, a concept must go through a scientific community... and define what science is... it has features that ... are their own because it is a culture ... the fact that there is not a single definition, it is because of this mutability ... (BT-6).	It is a system that acquires knowledge based on methods, scientific methods. Science is a culture with its own characteristics (PT-2).
Culture... with features, language, ways of communicating... Like other cultural groups also have. It's what makes being validated within it ... science as a way of explaining the nature validated by a group, which is the scientific group (BT-8).	Hey, what is science? Difficult! Science has to do with facts, with the method ... Science has a method, has a goal. It is knowledge that is acquired by various methods, goals. Science has to do with culture, the scientific culture (PT-3).
Community... that produces knowledge and this knowledge is scientific knowledge... studying and allows other scientists to study from their discoveries... something that is not ready... you can always find new discoveries with the day to day... (BT-9).	Science ... it's still hard to explain! Well, science is a cultural activity of scientists... that produces scientific knowledge through scientific methods... That's it! (PT-4).

The attempt to define the term science is not an easy task and, indeed, there is not a single epistemological position among philosophers of science. This difficulty was also identified by Brazilian and Portuguese teachers, not only before (Table 1) but also after their participation in the TE-CD course (Table 2). After the course, teachers BT-6 and PT-3 attributed the absence of a unique concept for the term "science" due to the variability of the scientific activity itself:

"There isn't a unique concept [of science] ... it has to do with the natural ... in fact it isn't immutable ... to be scientific, a concept must go through a scientific community... and define what science is... it has features that ... are their own because it is a culture ... the fact that there is not a single definition, it is because of this mutability". (BT-6). "Hey, what is science? Difficult! Science has to do with facts, with the method ... Science has a method, has a goal. It is a knowledge that is acquired by various methods, goals. Science has to do with culture, the scientific culture". (PT-3).

Despite demonstrating difficulties in defining the term science, the Portuguese teacher PT-3 revealed an adequate conception of science as a cultural activity of scientists. In addition, after the TE-CD course he was able to conceive that scientific activities are not conducted by only one method, but rather by several methods (compare PT-3 before and after the TE-CD course, Tables 1 and 2, respectively).

Also after the course, the Brazilian teachers' conceptions of science improved as shown by the above BT-6 speech, but also BT-8 and BT-9:

"Culture... with features, language, ways of communicating... Like other cultural groups also have... science as a way of explaining the nature validated by a group, which is the scientific group". (BT-8).

"Community... that produces knowledge and this knowledge is scientific knowledge... studying and allows other scientists to study from their discoveries". (BT-9).

They conceive science as a culture that has its own language and investigates natural phenomena (BT-8) and that it is historical and has a specific field of research that conducts and enables new discoveries (BT-9). After the TE-CD course, in general, Brazilian teachers achieved an appropriate definition of science but one of them, BT-5, showed insecurity in her speech, as she not only agrees with the idea that scientific activities are just about the natural world but also accepts the possibility of studying supernatural phenomena:

"[Science] is the path that will allow understanding the natural world ... science does not work with the supernatural world but when I see certain things that was not the domain of science being researched, so I'm wondering". (BT-5).

On this issue, one must consider that for defining science it is important to question its nature, including the set of its specific features, which in turn are shared by scientists of a particular period. One of these features, as Cobern & Loving (2001) declare, is that scientific activities are just about the natural world.

After the TE-CD course, the Portuguese teachers extended their conceptions of science, understanding it as an inherent cultural activity of scientists. However, as it happened before the course, they kept focusing their definitions on the methodological aspects of scientific development as the four teachers (PT-1 to PT-4) say:

"Science is a proved experimental method, through a way which is usually a journal ... and that is recognized by a group as such. Science is one culture, because there are other cultures". (PT-1).

"It is a system that acquires knowledge based on methods, scientific methods. Science is a culture with its own characteristics". (PT-2).

"Science has to do with facts, with the method... Science has a method, has a goal. It is knowledge that is acquired by various methods, goals. Science has to do with culture, the scientific culture". (PT-3).

"Science is a cultural activity of scientists... that produces scientific knowledge through scientific methods". (PT-4).

These teachers left out the other characteristics that are peculiar to scientific activities, for example, that science is historical. In fact, Cobern & Loving (2001) claim that science involves a set of theories, activities, ideas, habits, norms, values etc. that are shared by the wide scientific community, being socially and historically constructed. The absence of historic and epistemological perspective of science by the participants may be due to the complete lack of these subjects in their regular teacher training process.

4. Final Considerations

Before the TE-CD course most teachers did not conceive that in their teaching of science they should assume science as a cultural activity of scientists. By participating in the course on *"Contributions of Ethnobiology, History and Philosophy of Science for Teacher Education addressing Cultural Diversity"*, Brazilian and Portuguese science teachers extended their conceptions about the nature of science.

In a broader sense, this implies that teachers can reflect and assign new meanings to their pedagogical practices in relation to the intercultural dialogue, especially regarding the creation of opportunities for students to understand science as one among the numerous existing cultures. Thus, not assigning hierarchy of science towards cultural knowledge of those students who may have values and contexts that are specific to the social environments where they come from.

It was interesting to note similarities and differences between the Brazilian and Portuguese teachers' conceptions either before or after their participation in the TE-CD course. In short, the Brazilian teachers, although with some difficulties, showed a broader definition of the term science as compared to Portuguese teachers. The former characterized science as knowledge, as a culture that has its own language and it investigates natural phenomena, being historical and demarked in specific fields of research and that performs and makes possible new discoveries. In contrast, the Portuguese teachers focused their science conceptions to the knowledge produced by scientists and the scientific method.

The fact that there are differences between the conceptions of Brazilian and Portuguese teachers may be directly related with their previous undergraduate training, as well as their wider social and cultural environment. In the case of Brazilian teachers, it is possible that they have more training on the nature of science related to the sociology of science, which considers the influence of external factors on the development of science. In Portugal, the science teachers training may be more linked to the positivist view of science, which is based on the idea of science as a value-free activity and separating the relation between science, technology and society (Gil-Pérez et al., 2001).

It can be concluded from this preliminary study that further research with larger samples of participants in both countries is of paramount importance in order to elucidate in more detail the differences not only between the science teachers' conceptions about science but also between their teacher training in Brazil and in Portugal. This will generate data that will contribute to improve science teacher training curriculum in both countries, with special reference to cultural diversity.

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