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The Choices of Teachers in Training in Chemistry Using a Thematic Teaching Material

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Abstract: The introduction of STS approaches has been the challenge of teachers in general, and the focus of several studies in the field of education. The specialized literature of the area has indicated that one of the difficulties in teaching with STS focus may be related to the misconception of teachers about the Nature of Science and on Science teaching. This article presents data regarding the choices related to the use (or not) of STS resources present in a thematic material. We analyzed the practice of teachers in training, as well the choices they made during the use of this material, to help us to understand the conceptions about Science and Science teaching that they were constructing during the participation in a teacher training project. We perceive an innovative teaching practice, but the participating teachers have misconceptions about the Nature of Science.

Key words: preservice teacher education, STS, teaching material

1. Introduction

Despite being part of the research agenda in education and science for over four decades, education focused on Science, Technology and Society (STS) relationships is still incipient in classrooms (Dagnino, Silva & Padovanni, 2011; Mansour, 2009). Mansuor (2009) argues that one of the causes is that most science teachers are not prepared to teach using the STS approach. Given that the performance of the teacher is crucial for this type of proposal to be successful, the training of this professional is crucial when considering a teaching practice more focused on the interests of students.

Mansuor (2009) believes that the teacher must have deep knowledge about the concept of STS and its philosophical bases, arguing that the beliefs held by the teachers are determinants for their behavior in the classroom; therefore, teachers must restructure their beliefs and values during the various stages of their training. The author also argues that one of the causes for the teachers to be unprepared lies in the inadequate conceptions about the science they hold.

Given this context, the need to consider the Nature of Science (NOS) in teachers' training becomes clear, so that their conceptions about the construction of knowledge, of scientific work, and the idea that science is not neutral can evolve or be constructed throughout their training. For Ledermann (2006), in general, studies on the

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nature of science include knowledge about epistemology, history, culture and philosophy of Science. These are considered to be complex studies due to being "meta-knowledge arising from the reflection of Science itself" (Acevedo et al., 2005, p. 2), which makes the understanding of the Nature of Science a potentially difficult one. This more realistic understanding of Science can be considered one of the fundamental factors for STS Education to have a greater role in the work of teachers.

The specialized literature of the area presents investigations dealing with the conceptions that practicing teachers and teachers in training have about the Nature of Science (Gil-Pérez et al., 2001; Vilela-Ribeiro & Benite, 2009; Tavares, 2006; Junqueira & Maximiano, 2011). In general, these studies indicate that teachers present inadequate views about NOS, with the prevalence of an empirical-inductive understanding and that such understanding usually undergoes little change at the end of a scientific course. Gil-Pérez et al. (2001) indicate that when teachers believe that science is primarily constructed by the scientific method and that knowledge is thus an irrefutable truth, it defines how these professionals will teach. In these cases, the contents are presented as finished, without discussing their historical construction and the questions and issues they arose.

Some studies analyzed data that indicate that such inadequate conceptions can evolve into more realistic views when training courses discuss issues such as the history and nature of science more explicitly.

Corroborating these authors, we believe in the importance of developing training activities that lead teachers to perceive and reflect on their beliefs and thus to evolve in their own conceptions, not only about the Nature of Science and STS but "the conceptions they have about teacher, teaching, learning, school, etc. and how they were constructed" (Quadros, 2005, p. 7).

This article is part of a master's study that accompanied the use of a specific teaching material, written with the intention of facilitating teachers' appropriation of some contemporary trends of teaching, mainly the STS relations and the changes of speech in the classroom. Here will be presented data on the choices regarding the use (or not) of STS resources present in the thematic material.

2. Initial Teacher Training and STS Education

The training of teachers has been a regular subject in educational research, and much has been discussed about the factors that interfere in their training. According to Carvalho & Gil-Pérez (2011), although teachers in initial training tend to express some rejection to traditional teaching methods, they continuously reproduce this model in their professional practice, a situation also shown by Quadros et al. (2005), Catani et al. (2000), and Freitas and Villani (2002).

Almeida and Nardi (2013), when analyzing the publications of the past decades, affirm that the field of education in Sciences has shown great interest for the teacher, which is evidenced by the great volume of publications. For Freitas and Villani (2002) the field of training of Science teachers has made efforts to train a professional capable of incorporating theoretical reflections. In this sense, both the general contributions of the field and specific reflections of the area of Sciences are important. Teaching the Sciences of Nature is a great challenge for teachers, since one may have to deal with the possible lack of interest of students, with the alternative conceptions that these students have when explaining the world where they live in, and with the distorted understandings of Science. These possibilities will certainly make the teacher use diversified strategies both to include the student in the class dynamics and to assign meaning to the concepts that are discussed in the classroom.

For Carvalho and Gil-Pérez (2011), as important as scientific knowledge itself are the didactic-pedagogical knowledge of one's performance area, with regard to both the epistemological and historical aspects, requiring from the teacher the capacity of relating the political, economic and social contexts. Teacher training courses currently have the great challenge of training teachers capable of understanding the epistemology of Science, and from there propose and organize classes that are comprehensive and contemplate not only scientific content, but its relationship with the students' current context.

Carvalho and Gil-Pérez (2011) bring an important reflection about what pieces of knowledge Science teachers need to share and thus what are the training needs to break with the simplistic understandings about teaching. For them, teacher training courses — both initial and continuing – must incorporate what academic research has shown to be important to produce learning in Science, especially proposals from constructivist orientations. In the field of training of Science teachers some trends are discussed as possibilities for the improvement of teaching, and among them are some of the assumptions of the Science, Technology and Society (STS) movement.

According to Santos (2011), STS studies in science education "emerged clearly in the context of discussions about the role and implications of science in society" (Santos, 2011, p. 28) and were broadened to the formation of citizenship. Santos and Mortimer (2002) emphasize the need to develop values such as "conscience, social commitment, reciprocity and respect for others" (Santos & Mortimer, 2002, p. 5), and that critical citizens committed to the society can only exist from the construction of these values.

Aikenhead (2005) argues that the goal of science education is to train citizens capable of acting in a world increasingly permeated by science and technology. Therefore, students must learn to relate scientific knowledge to technological production and to the effects such technology has on society. The author claims that a crisis in scientific education exists and argues that it stems from three important factors present in traditional education: the little involvement of students, the perpetuation of myths about Science and the little meaning that science education has for students' lives. The article discusses results from studies that show that students do not use canonical science contents to solve everyday issues or make decisions that involve scientific knowledge. The author argues that the science taught in school must be transformed into a practical content that assists in decision making and is meaningful in the everyday life. STS Education can thus be a good alternative to overcome these shortcomings since the relevance of scientific knowledge is one of the central points of STS-based curricula.

Zeidler et al. (2005) criticize the STS when advocating the use of social and scientific questions in Science classes to develop reasoning and ethical and moral values, arguing that such approach has innumerable limitations due to the lack of a consistent theoretical structure. Considering that many proposals for the use of NOS and social and scientific questions have surfaced among the proponents of the approximation between Science teaching and the STS assumptions, our position is different than the one taken by Zeidler et al (2005).

Regarding the NOS, Cachapuz et al. (2005) argue that their research has resulted in deformed understandings of science. According to them, the teaching of science has conveyed a reductionist and distorted understanding of science, one that presents it as removed from any context, individualistic and elitist, empirical-inductive, rigid, algorithmic and infallible, unproblematic and ahistorical.

Contemporary society has increasingly required the understanding of the consequences of technological advances from its citizens and, consequently, the ability to analyze and perceive political and economic interests related to these advances. The teaching of Science represents the opportunity for this to happen. In this sense, there are several proposals for science teaching based on STS guidelines, especially the teaching from contextual themes.

The use of STS themes to develop scientific knowledge in the classroom has been understood by some authors (Santos, 2007; Quadros, 2004; Silva, Shuvartz & Oliveira, 2014; among others) as a good opportunity for students to comprehend the direct relation between the Natural Sciences and the social context and developing interest in science, thus becoming more involved in the classes. Silva, Shuvartz and Oliveira (2014) emphasize that teaching through themes is an "intrinsic characteristic of the STS approach" (p. 108) because it starts from the student's daily life problems and leads them to "assign meanings when studying a given topic" (p. 108).

However, as a framework of science teaching that is also partially rooted in STS studies, the understanding about the nature of Science is a crucial training need. In addition to teaching through topics of interest to Chemistry and the students, we sought to consider the practice of teachers in training and analyze whether the choices they made throughout the classes could help us to understand the conceptions about Science and Science teaching they were constructing during their participation in the project and use of the material.

3. Methodology

This study was developed in an immersion in teaching project held in the Department of Chemistry of Federal University of Minas Gerais/Brazil. Participants in this project were students of the Chemistry teacher training course, and teachers of Basic Education of the public network of the State of Minas Gerais, who acted as supervisors. The aim of the project was to plan and develop classes with environmental themes to stimulate teacher training, inserting them in another way of teaching that was not guided by the mere transfer of information without any attention to the meanings attributed to such information. Some other contemporary trends in education were also present when teaching Chemistry through contextual themes.

The project had weekly meetings of the members so they could discuss the lesson plans and reflect on the teaching practice as a group. Future teachers evaluated the classes during the reflections. The classes emphasized students' participation, the evaluation of the teaching material, and the strategies used during the practice. The classes were taught at three public schools in the metropolitan area of Belo Horizonte, Minas Gerais, and were organized as an extracurricular course offered to the students. The students were invited to participate and did so without any connection to the school's formal discipline.

The organization of the classes was based on a teaching material that considered some contemporary trends of teaching (teaching from themes, interactive and dialogic classes, students' involvement in classes, among others). All classes were planned from themes. The proposal of the chosen teaching material was to understand a given theme from the use of scientific concepts that are studied to explain natural phenomena.

In addition to the themes, the material presents several questions for discussion, which are distributed throughout all classes. These questions were inserted to facilitate the moments for the discussion of ideas in the classroom. The material also offered varied activities to the students, such as experiments, texts for reading, as well as explanatory graphs and figures. The material was initially divided into three modules, corresponding to a set of four or five classes each. The modules dealt with: a) Water Cycle; b) Water in Nature; c) Water and Plants.

We accompanied 17 undergraduate students in Chemistry Teaching at Federal University of Minas Gerais when they participated in the Motivating Practices in Chemistry Teaching Project. The term teacher in training will be used to refer to them. The fictitious names Patrícia and Rodrigo were used to refer to specific teachers. Data from the weekly group meetings and from the weekly followed classes are included in the corpus of this article. Data were recorded by filming the meetings and classes. Data were captured in digital format after the filming period. All videos were watched in full. We selected some occurrences in which we can identify the choices made by the teachers in training in relation to the contents present in the teaching material.

The selected occurrences were transcribed. Regarding the transcriptions, the symbol represents a significant pause in speech, and the symbol […] represents a cut in the transcribed sequence. Although we may have made some inferences, we chose to punctuate the speech based on the intonation used by the speaker. We believe this makes it easier for the reader to understand.

4. Results and Discussion

During the meetings of the team involved in the project some conflicts related to the use of the material and how such use would affect the teachers' classes occurred. Given that each module dealt with a theme and had many activities, the teachers in training were apprehensive during the weekly meetings, fearing they would be unable to develop all the planned content and promote student participation. During the lessons it was noticeable that the teachers in training made choices regarding the content addressed and the resources contained in the modules so they could value the interaction with the students in most cases. Texts, curiosities, and information that were added to the material that were not in the prior planning were often left out, probably due to time constraints.

We focused our attention on such selection of contents/activities when we realized that these choices were being made, so we could analyze if the choices made by the teachers in training could help us to understand the conception of Science and Science teaching that these subjects were constructing during their participation in the project.

Some technological questions were present in the material such as a topic on the difference between pasteurized and UHT milks after a discussion about the classification of milk as a heterogeneous mixture. It was suggested to conduct this discussion with the students, and to discuss the advantages and disadvantages of UHT milk when compared to pasteurized milk. This discussion was presented as a proposal teacher could use during class. However, the time that would be spent for this was always a concern of teachers in training. We selected a fragment from teacher Patrícia's class and transcribed it below:

> Patrícia: Now, have you considered milk? [...] Normal milk, do you think it is a homogeneous or heterogenous substance?
>
> Student 1: Heterogeneous.
>
> Patrícia: Heterogeneous? […]
>
> Patrícia: So why does the milk package have "homogenized milk" written on it? [...] If milk is a heterogeneous substance, how can it be homogeneous? // What does homogenized mean?
>
> Patrícia: Can you see two phases in milk? You cannot. So, what is homogenized in milk?
>
> Patrícia: Milk fat. So, during the milk treatment process, it undergoes a process … check page 43. Fat is like a globule. [...] This fat will go through sieves and these sieves will make these globules grow smaller until being very small […]
>
> Patrícia: The second thing that is written there is the difference between pasteurized milk and UHT milk. Have you ever heard of this?

Patrícia was the only one to conduct this complementary discussion about milk. The others chose not to explore these topics, despite the subject having been explored during the planning meetings. We observed that the other teachers in training who conducted this same class chose to assign more emphasis to the chemical concepts, leaving the technological question related to milk as complementary reading to be done at home.

Other recurring examples refer to texts containing news from newspapers, which were used as a way of relating the content of classes with context situations. As an example, we present an excerpt from Rodrigo, who used another additional text box containing two newspaper reports on hail precipitation. The presented section occurred during the investigation of how the relative humidity of the air can influence the evaporation of water; the objective at that point was to introduce the concept of vapor pressure. As indicated in the material, Rodrigo discussed the fact that some cold regions are very rainy. The following is an excerpt of how he introduced this discussion.

> **Rodrigo**: […] We will see that in order for precipitation to happen we must consider climatic factors as well. Look at page 13. These two news articles here. // [...]Let's see the headlines. "Excess rain in winter affects strawberry crops in São Paulo". The other one is: "Winter and spring rains have damaged citrus quality". So, we cannot confuse that. At lower temperatures the water cycle continues to occur. Which means that the evaporation of water also continues to occur.

Although he did not read the news articles, Rodrigo used them as a way of relating scientific knowledge to daily facts. The other teachers in training who taught this class did not use this news in the classroom. Some indicated the reading at another time (usually at home) as a complement to what was studied, whereas others ignored the presence of these news articles in the teaching material that they used.

During the group meetings, the conflict between allowing/encouraging students' participation in classes and the amount of content present in the teaching material was explicit. However, during the classes we can observe that teachers in training made their choices quite naturally, selecting certain points from the script and leaving others aside. What does this tell us about their conception of Science teaching? We are aware that due to already being involved in an immersion project in teaching for some time and because they have been working with Science teaching from contextual subjects, these future teachers are in the process of appropriating an "other" way of teaching that does not follow the information transmission model.

The options they made in terms of activities/contents were to allow the participation of the students in the dynamics of the class and the discussion of different points of view. However, in making these choices, most of them focused on the conceptual discussion rather than world-reading. We know that reading the world from the Science point of view depends on a rigorous conceptual deepening. But we believe that the construction of meanings for scientific concepts is favored when this concept is directly linked to a context. By choosing not to discuss some contextual situations directly related to the subject in question, these teachers may be considering the concept as the priority, to the detriment of understanding the phenomena and the technological artifacts found in the world.

The presence of technological questions is a premise of the STS movement, so students are able to perceive the relationship between Science and technology, but mainly the effect that both have on their lives. By putting aside some of this "complementary" information, it was precisely the discussion of technological artifacts in our lives that was left unconsidered.

The discussion about the water cycle was introduced via a terrarium made in a PET bottle, using soil, some coal, water and a plant. This system was closed and shortly after the formation of water droplets in the upper inner part of the bottle could already be seen. The water, which had already evaporated, was condensing as it came into contact with the wall of the bottle. Teacher Carlos discussed this phenomenon extensively with the students, directing the student's attention to the occurrence of this very phenomenon in nature. The following transcript illustrates how the discussion occurred:

> Carlos: So, this cycle here (points to the terrarium), can you see it happen in nature? In our environment?
>
> Student 1: Yes.
>
> Carlos: Yes, so can we say that this terrarium is a reproduction of the water cycle that happens in the environment?
>
> Student1: Yes.
>
> Carlos: Okay. // But we do not have the physical barrier of the bottle, right? Show me (pointing to a student) where evaporation occurs in the environment. For example, the water that evaporated here, from what I in there, that water evaporated. And the evaporation process in the environment, where that water comes from?
>
> Several students speak at the same time.
>
> Carlos: All this water evaporates. But in our terrarium there is the physical barrier and in the environment there is none. So how will the water cycle happen?
>
> Student 3: The water will arrive in a colder region of the atmosphere.
>
> Carlos: A colder region. Water condenses there. We can see that what happens in the terrarium also happens in nature. It's the water cycle. Do you agree with that?
>
> Student 4: Yes, it's like a mini… It is a model of our world.
>
> Carlos: She said model. Why do we say "model"?

Carlos uses what Student 4 says, valuing it. From this, the teacher goes on to explain the terrarium as a model of the water cycle but emphasizes its limitation since there is no physical barrier where water can condense in nature. He warns that even if limited, the model helps us understand the water cycle. From this discussion he mentions other models used by Science, which also represent an explanation for the phenomena of nature. Like Carlos, other teachers in training — although not all participants — also treat Science as a way of explaining the world around us.

From this example of what happened in Carlos's class we can perceive a conception of Science as an explanation rather than a positivist conception, in which scientific knowledge is recognized as true knowledge. To us, it seemed that by valuing the word "model" and expanding its use to other examples of Science, Carlos is more likely to perceive Science as the result of human conceptions or to better deal with the nature of Science.

Although limited in this article, the data show us that the way these teachers in training presented Science to students and the choices they made regarding content may be related to beliefs about teaching and the nature of scientific and technological knowledge that these professionals have, as pointed out by Mansuor (2009). At all times when Science could be criticized, we identified that teachers avoided doing so. For this reason, we corroborate Mansour (2009) when he states that it is only through the understanding of ideas such as the non-neutrality of science that a realistic use of STS themes and all its social implications can be performed and valued. As argued by Gil-Pérez et al. (2001), these inadequate epistemological conceptions about the nature of knowledge can be considered as one of the main obstacles to the renewal in scientific education movements, as is the case with the use of assumptions of the STS movement in Science classes.

5. Conclusions

From the analysis of the observed classes, we identified that when experiencing a conflict about time/content/dialogue, most teachers in training chose to value theoretical content rather than additional resources that could bring the context even closer. Those who chose to use such resources did so at different levels of depth. To us, it seems that despite understanding that teaching from a contextual theme is a good possibility for inserting students in the dynamics of the class and promoting learning, the attention to the amount of content is still excessive. Even the insertion into “another way” of teaching was not enough for the teachers in training to evolve in the conception that teaching Science is working with a large amount of information. The selection of concepts that allow the student to continue learning is still a challenge to be faced in teacher training.

When following the classes, we noticed that some of these conflicts were apparently solved by most of the research subjects. Teachers who were followed made content choices at some point, and usually chose to leave aside resources that could help work the context. These options may be an indication of inadequate conceptions about teaching, science, and technology that lead teachers in training to choose to value theoretical content rather than broader discussions about technological artifacts and student context. Given this discussion, the importance of considering aspects related to the Nature of Science in the training of teachers is perceptible, so their conceptions about the construction of knowledge, of scientific work, and of the idea that science is not neutral can evolve or be constructed during their training, and that these future teachers are convinced of the importance of this type of discussion in the classroom. This more realistic understanding of Science can be seen as one of the fundamental factors for STS Education to have a greater role in the work of teachers.

Teacher training courses have the responsibility of promoting the incorporation of practices that help to overcome the current model of Science education that prevails in many of our schools. Moreover, professionals trained in these courses must understand Science as a human construction and not as a mere neutral activity, distant from social problems. The epistemological reflection must be promoted both during teacher training and the teaching activity itself. Constructing a proper view of Science and Science teaching is a commitment of the entire scientific community.

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