A problematizing STS education proposal: the case of Monte Carmelo's ceramics

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Abstract

In this study we aim to present the paths taken for the elaboration of a teaching proposal based on the problem of the Monte Carmelo's ceramics and the proposal itself. Our question was: how to develop a proposal of problematizing STS education from a local problem so that similar actions may be promoted in other contexts by basic education teachers? We conducted a field research which consisted on structured interviews individually carried out with five workers of the ceramics industries and a visit to one of these industries. We carried out a study on clay and, after gathering this information, we began the construction of a teaching proposal. This proposal refers a proposition based on Freire's perspective called pedagogical moments. With the information collected from the field research we created a teaching proposal in a case study format. In it, we present a fictitious problem in which a new ceramic industry housed in Monte Carmelo would be having trouble to produce tiles, which were fragile and brittle. The cause and the solution for the case involved chemical knowledge and the socio-economic-environmental issue experienced in the city. The developed proposal showed to be promising as reference of a problematizing STS education for the teacher. It must be evaluated in practice, which is the continuation of this study.

Keywords: problematizing STS education; pedagogical moments; Monte Carmelo's ceramics; teacher formation.

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Introduction

STS education - Science-Technology-Society - aims the formation of citizens able to understand the relationship between science, technology and society to critically position themselves on this.

STS education is credited for its focus on the processes of current technological systems and the possibility to include the risks of these and their imposition of cultural values. This perspective also includes the possibility to include societal issues showing the contextual dependence of technology used and the scientific theories behind it. Some Brazilian researchers recognise a close relation between this view point and the perspective of Paulo Freire's (2000) which may pronounce the importance of including a broader perspective when designing STS education (Auler and Delizoicov, 2001, 2006; Santos, 2006, 2008).

According to Freire (2000), education enables citizen education from the moment it overcomes the education assumes that the student knows nothing and the teacher is the owner of the knowledge and values relations between the specific contents and the social, cultural, political and economic context in which students are inserted. That would be liberating education. In it, the programmatic content is built together, in the mediation between teacher and student, in the dialogicity, that the programmatic content is established, initiating the investigation of the thematic universe.

We believe that the teacher formation in this aspect is necessary so that we can provide the STS education at school. Therefore, we developed a teaching proposal using a chemical social theme to be applied in basic education. Our question was: how to develop a proposal of problematizing STS education from a local problem so that similar actions may be promoted in other contexts by basic education teachers? In this study we aim to present the paths taken for the development of teaching proposal based on the problem of the Monte Carmelo's ceramics - a Brazilian city - and the proposal itself.

Delizoicov, Angotti and Pernambuco (2002) developed a proposition based on Freire's perspective called pedagogical moments, consisting of three steps: initial problematization, organization of knowledge and application of knowledge. In the initial problematization real situations are placed and problematized, and students are involved and challenged to understand them. In our case, the proposed situation is the case of Monte Carmelo's ceramics. In the organization of knowledge, necessary knowledge is sought for understanding the problem-situation and, finally, the application of knowledge, in which it is intended that the student is able to articulate the situation studied with other similar from the acquired knowledge. This proposition of the researchers in question is consistent with a problematizing STS education.

Presenting the teaching proposal

We aim to present the proposal for the teaching of intermolecular interactions from the depiction of the city of Monte Carmelo, which involves the production of clays and some socio-economic problems faced due to the crisis of ceramic industries.

In designing the education plan, our basis was the fundamentals of STS education in which the science education aims to "the comprehension of the scientific content and social function of science" (Santos, 2007, p. 478). STS studies have some multidisciplinary characteristics and are guided by the inter-relationships built between science and technology and its effects on society, both in terms of the political, economic and cultural aspects, as well as the transformations that can cause social and environmental, relating, therefore, with formation of citizenship and, in a broader view, with human rights. The development of all planning was founded on a case study with social-scientific aspects (Sá and Queiroz, 2009). In this, were presented a fictional problem that is happening with a newly installed ceramic industry in Monte Carmelo. To solve it, students need to know: the properties and transformations of clay to produce ceramic tiles, the production process itself and the situation experienced in Monte Carmelo - the environmental problems created by the extraction of clays, lack of labor rights, unemployment and the migration of skilled ceramic workers.

Next, we present the elaborated case.

"The case of a ceramic industry recently installed on Monte Carmelo"

The city of Monte Carmelo had its economic development peak in the 90s due to the production of ceramic materials. The same was known as the capital of tile due to the monopoly of production. The construction of the new capital and big investments in civil construction were some of the reasons that led the production of tiles and bricks. All this success of ceramic materials aroused the interest of the entrepreneur Ms. Antonia Silício, who came to Monte Carmelo aiming to set up a small ceramic industry. However, the entrepreneur is finding some challenges in her project. The hiring of skilled labor was, strangely, almost impossible. But the entrepreneur hasn't given up and soon hired new employees, even if they do not have experience in the field. During the production of ceramics a problem came up: the clays, when taken to the molding process, do not stick within the desired shape because the material was too soft.

Given this situation, Antonia Silício, comes through this letter, ask for your help, students and

chemistry teachers, to solve the problem founded in the production of ceramic materials.

To accomplish our study, the first step achieved was a research about Monte Carmelo city, mainly based in field research, which included structured interviews with workers and a visit at a ceramics industry to know about the production process. We made individually interviews with five workers and their statements were recorded. The workers reported on: working conditions, labor rights, remuneration, impacts on their lives with the crisis in this sector. The interviews were transcribed.

Knowing the Monte Carmelo's history and its ceramics

The Monte Carmelo city is located in the west of the state of Minas Gerais and was founded in the nineteenth century by prospectors in search of diamonds. The city went through a big crisis with the depletion of these gems, and because of that, it had to reinvent itself and find a new way to generate income. As the diamonds extraction, the solution to this crisis also provided the exploration of the region's soils, but now the clays have become the most valuable asset of this town (Gontijo, 2007).

Clays are the fundamental constituents of various types of soil of different regions of the world. In its natural form it is used for diverse purposes such as treatment of certain types of diseases and various esthetics treatments that have become popular nowadays. However, the nobler and better known use of clays is the production of ceramic objects. This is such an ancient activity that is not possible to date precisely its beginning, but probably it happened in the fire Age: it is assumed that early humans found that some types of clay got hardened when was near bonfires and, from this observation, they began to improve techniques and develop various ceramic artifacts that are found today in many archaeological excavations (Schmitt and Avello, 2013). So since fire Age, ceramics are present in all societies and, probably, you are surrounded by different types of ceramics right now.

In Monte Carmelo, the ancient knowledge of the clays' properties and production processes, resulted in a large production of tiles and bricks by the red ceramic industries of the town. This production was boosted with the construction of the new federal capital of Brazil and by large investments in the civil construction sector. Due to the great ceramist development, the city of Monte Carmelo was considered in the 1990s, the "Minas Gerais Tile Capital" and the "City of Chimneys". The ceramic industries were very important for the economic development of the city. In 2000 they totaled 49 industries, generating around four thousand jobs (Mariano, 2010).

The ceramics' production process, until the early 1980s, was quite artisanal and was marked by physical fatigue and by dangerous procedures used during the manufacture of tiles and bricks. One of the workers of this period, Mr. Carmelito points out in his speech, the working conditions it has undergone.

Formerly I use to enter in the oven with about 180 Celsius degrees. I used to picked up the tiles from the oven ... It was very bad, but Formerly we did not wear gloves. It was line bag, no one had money to buy gloves. He worked using a slipper (called havaiana). A lot of people died in ceramics like that ... I had a heart disease, but we don't had any access to any doctor, right? We worked anyway because if not I loosed the day.

The lack of personal protective equipment brought for some workers serious health problems, such as Ms. Carmelita, who worked in ceramics since the age of ten and had to leave work after a while due to an allergy acquired in hands from contact with the oil used in the production process. In addition, due to poor working conditions, the workers of the ceramics did not have their labor rights respected. Mr. Carmelito for working several years in the ceramics, also went through these problems.

When I was 10 there were no formal contract. No one had it. I used to work in a kind of pottery. When I was 19 I had a formal contract. Formerly, no one had a signed contract. When It was raining, we didn't work. The boss did not care about you.

In 1990 came the Tiling Industry Workers' Union. It has as objective vindicates the rights of workers, however, it was not recognized by the bosses who did not enter into an agreement with the employees on strike situations. In addition, trade union leaders were sent away from their services as a form of punishment by the manifest. In 1993 the trade union was legalized. From then, this trade union began to take legal proceedings against the employers and the workers began to participate in the decisions of the Workers' Union and were aware of their rights. In 2001, with the organization of strikes and by complaints, the workers managed to get the percentage of them without a formal contract fell from 80 to 20% and, today, workers have their contracts signed with the real value of their wages (Mariano, 2009).

The general manager of one of the city's ceramics, Carmelo, reported that at the beginning of the 21st century, the industry experienced some difficulties, leading to the closure of thirty-two industries, which caused a big economic crisis in the city.

The development of ceramic in Monte Carmelo happened without great concern with the environment, which suffered many impacts due to the indiscriminately clays' exploitation, without any recovery of the explored area. Furthermore, most of the deposits was not legalized. Along with the barriers embargo, another difficulty was the "wood

crisis". As the clay, the wood was the raw material for the production of ceramic materials, being used as fuel combustion in furnaces.

The workers, even in poor working conditions, fought for the ceramics industries were not closed and for the end of the embargo, because it was the work which they drew the support of their families.

We even went up to the woods to protest there. (Carmelita).

As we are at the capital of tile and there were lots of ceramics, if there was no clay, if the clay was not available for people to work with, everybody would be unemployed. As there was only ceramics, there were nobody enabled for another job. People were not educated. So they had to fight for this cause. It was about ceramics and wood. Formerly, wood logs were used to burn. They were banned because of the environment, which was too degrading, but there was an agreement that allowed certain amount. Today we still have this situation, we don't take just from here, we take from other places too, but in the past we were more dependent. (Carmelina).

Due to these facts, the number of unemployed of the city increased considerably, promoting a migratory flow of workers to other cities.

Look: from 400 people in the ceramics, there were only 90 left. Most people from Monte Carmelo, the pottery workers, went to Catalão, to Manaus. Four buses were crowded with pottery workers' families. They went also to Mato Grosso. Today, in town, there are only six ceramics industries. (Carmelito).

The ceramic industries that had managed to maintain its activities during and after the crisis have focused on the quality of their products to win back the market and had to adapt to the work safety standards and also to environmental preservation.

Today everything is formalized. You don't miss a work day because of the rain. Today there are doctors, every industry has a doctor. Every 15 days, or every month medical exams are made. Everybody in gloves. They give people uniforms. Only the t-shirts. And boots. Nobody leaves the bathroom – there are two bathrooms there – in flip flops. (Carmelito).

In the company there was no work safety technician, you know? It's changed lately. Now it's offered. And they give us Uniforms, PPE [personal protective equipment] and all kind of work equipment, you know? Even the uniform to work. (Carmelina).

Moreover, with the advent of technology, new machines were introduced in the industries, which caused changes in the production sector and the staff. With the arrival of new machines, the workers felt that this would be allied to develop the hard and dangerous work. However, the machines were more than allied: they took the place of many workers, increasing the unemployment.

Today it's automatic, right? No one is needed anymore. It's just necessary to take the tile waterspout. Only this. Employees had being affected, right? Each ceramic spent ... Let's assume: ten presses spent five workers. Today one person is enough. All the rest was fired. (Carmelito).

To solve the crisis of ceramics, the economy of Monte Carmelo was diversifying, and the city no longer depends on the production of tiles and bricks. But the ceramic industries that remained not sought alternatives to the raw material abundant in the area and all the problems faced due to the crisis are still remembered and influence the lives of many inhabitants of the city.

During the visit in the industry, which was conducted by an employee of that, we made the recording of images about the production stages and the feedstock through photographs.

Figure 1- Clays used in the manufacture of ceramics.

Figure 2 - Resinous tiles produced from the clay

Knowing the clays

Clays belong to the group of the aluminosilicates which are formed by the chemical element silicon (Si), aluminum (Al) and oxygen (O), presenting, in smaller quantities, elements such as magnesium (Mg), iron (Fe), calcium (Ca), among others (Chagas, 1996). These chemical elements, especially silicon and aluminum, form two basic units that are essential for the formation of clay.

The first consists of a tetrahedral structure which the cation of the silicon atom is in the center and is attached by covalent bonds to four oxygen atoms or ions that occupy the vertices of the geometric structure. The second unit has an octahedral geometry with the aluminum cation located in the center. The vertices are oxygen atoms or groups covalently bonded hydroxyls aluminum (Zatta, 2010). Occasionally, the central atoms of the basic units may be replaced by Fe^{3+} e Fe^{2+} in the tetrahedral groups and Al^{3+}, Mg^{2+}, Fe^{2+}, Fe^{3+}, Ti^{4+} , Cr^{3+}, Mn^{2+}, Zn^{2+}, Li^{+}, in the octahedral groups, typically with a degree of isomorphic substitution (Gomes, 1986 apud Aguiar and Novaes, 2002). The representation of these basic units can be seen in Figure 3.

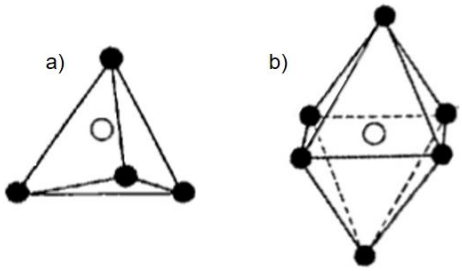

Figure 3 - (a) silicon tetrahedral structure e (b) aluminum octahedral structure.

The tetrahedral and octahedral basic units are connected to their peers so that they form continuous sheets (Santos, 1989). The tetrahedral and octahedral sheets can be represented as shown in Figure 4.

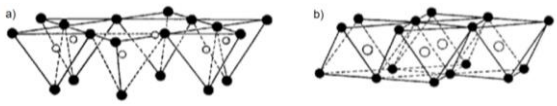

Figure 4 - (a) hexagonal sheets of silicon tetrahedra and (b) aluminum octahedra.

The stacking of multiple layers results in the formation of a clay crystal as the crystal of kaolinite (Figure 5), which is formed by stacking layers. In kaolinite layers are linked by hydrogen bonding, since there is a level of hydroxyl ions on one side of the layer (the octahedral sheet) and a plane of oxygen ions (the tetrahedral sheet) in the other layer immediately below (Santos, 1989).

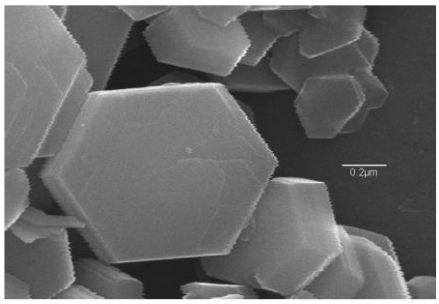

Figure 5 - the clays kaolinite crystals.

The surfaces of the clays' crystals have a negative charge which attracts the available cations. This, in turn, forms a layer of positive ions on the surface of the clays' crystals, making them separated by repulsion of charges of the same name (Atkins and Jones, 2006). The high affinity of the clay by the water is due to the presence of these charges on the surfaces of its crystals. The water, polar substance, undergoes the attraction of the surface charge of the crystal. This intermolecular attraction forms a kind of double molecular layer of water which is very adherent on the clay crystal. These double layers difficult even more the approach of clay crystals, increasing its flexibility (Chagas, 1996). When the clay is baked in an oven, their water layers are lost and strong chemical bonds are established between the crystals, resulting in a hard, durable material we call ceramics (Atkins and Jones, 2006).

Discussion of the case study

After the presentation of the case study, students will be encouraged to expose what they think about the proposed situation and what were your first impressions - initial problematization. In face of the responses of students, the teacher will mediate the discussions, to highlights all opinions and identify the main limitations and shortcomings presented by the students.

Initially, they will be asked the reason for the lack of labor to work on the installed Antonia Silício's ceramic industry. Many of these students had relatives or acquaintances who worked in ceramics that ended up losing their jobs due to the crisis that hit the sector, forcing them to move in search of new opportunities or work in other areas. Therefore, it is expected that students easily discuss this question.

Following clay samples will be carried for students to manipulate the material and perceive their physical properties. The Students can also add water to the clay. It is expected that students add enough water so that the clay cannot adhere to the desired forms. Thus, they will be able to analyze the problem that is happening to the Antonia Silicio's ceramics industry.

The next question to be raised on the agenda will be about the history of ceramics and its production.

At that time, the teacher will propose that students to do a field research - study carried out in our work - to know the history of the production of ceramics and the reasons that led to the crisis in this sector.

It is expected with this research, that students know how were the ceramics in the past, highlighting the number of employees, the dangerousness of the work and the reasons that led to the crisis and the process of modernization. In this regard, we note that at that time, students can realize that scientific and technological progress are not always in agreement with the social and moral progress, or even that "neither science nor technology are levers for changing which affects, in the best sense, what they transform"(Sachs 1996 apud Auler and Delizoicov, 2006, p. 343).

Technical visit

Students will be led to one of the city's ceramics industries. Before the visit, the results of research done by them will be discussed under the teacher mediation. On this visit, they will be able to know the current production process of ceramics and make a comparison of this process with the old one and notice the drastic reduction of workers caused by the machinery insertion. This is one aspect to be highlighted in a problematizing STS education, since it analyzes the process of the current technological system dominance, its risks and its imposition of cultural values. These observations will be taken up later in the classroom.

With this visit, in addition to observing the production process, students will have the opportunity to ask the workers what the amount of water needed to molding the clay, the temperature and the ideal time to let the clay molded in the oven and, so get a good ceramics.

At this point the teacher will have the key role to question students about the production of ceramic so that they realize the need to learn more about clay and its production process and chemically understand what is happening. For this, the teacher can ask questions such as: What is clay? Why should add certain amount of water? What happens if I add more water to clay? Why clay can be molded? Why when we heat the clay it became rigid? The teacher should start working with their students the needed chemical concepts to understand scientific concepts related to clays, characterized as a pedagogical moment, the organization of knowledge.

At the end of the visit, students will have enough information to produce a short text that will be delivered in the next class, answering the Antônia Silício and addressing, succinctly, the aspects related to history, crisis and ceramics production methods.

Final presentation

To end this teaching project would be proposed that students draw up a way to submit to ceramic industry employees the historical aspects of ceramic production in Monte Carmelo, the problems solutions they face and the scientific explanation of the processes involved in the production of ceramics. This presentation could be made through booklets, videos, oral presentation, drama and other forms that could be convenient.

Furthermore, it is important that other situations are placed for the students to they understand and reflect about situations of scientific and technological development, seeking other prospects for that.

Final considerations

The developed proposal showed to be promising as reference of a problematizing STS education for the teacher. It must be evaluated in practice, which is the continuation of this study.

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