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Aspects of regional history Ilhéus-BA as a source of content for the teaching of physics

Aspectos da história regional de Ilhéus-BA como fonte de conteúdo para o ensino de física

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ABSTRACT
In this article, we rescue the history of an old hydroelectric power plant in the rural area of the city of Ilhéus – BA through documentary analysis and interviews. We continue to give suggestions for working with physics and technology concepts for elementary school science teachers, which can also be extended to the physics discipline in high school. Although the content is of great regional relevance, our idea can be used for the study of relevant information for the teaching of science in other locations. We base our study on the STS (Science, Technology and Society) approach to science teaching. The perspective we adopt emphasizes scientific literacy with a view to citizenship, against the backdrop of the social importance of the theme. We also call attention to the rescue of the history and culture of a region for the teaching of physics and technology within this framework. Finally, we suggest strategies for the teaching of physics to be worked on according to the PCN (National Curriculum Parameters) of Natural Sciences for the final years of elementary school.

Keywords: Physics teaching, Electromagnetism, STS, History of Ilhéus – BA.

INTRODUCTION

The idea for this work arose when we did research in the city of Ilhéus with the intention of carrying out a PhD project in 2009. We used qualitative research as a methodology, as Ludke and André (1986) founded, in order to offer a detailed description of the historical facts related to the operation of the Almada Power Plant for the teaching of physics, collecting information through semi-structured interviews, testimonies, photographs, historical documents and books.

We visited some communities in the rural area of the region, as well as their respective schools, to investigate in these environments themes that could generate work proposals related to the teaching of physics and technology.

We started our search in Ilhéus in the Environmental Protection Area (APA) of Lagoa Encantada. In the beginning, we intended to associate the teaching of physics with the teaching

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of paleontology and geology, because in this region there is a field of research in these areas with a few decades of tradition. However, in visits to the communities of Castelo Novo and Lagoa Encantada, we found possibilities of teaching physics through the study of forms of electricity production present in those places. More specifically, we found small hydroelectric power plants built on farms around the aforementioned communities, as well as some houses equipped with solar cells.

But what caught our attention the most were the ruins of an old hydroelectric power plant on the banks of the Almada River (Figure 1), in Castelo Novo. We were informed about the plant by the principal of the municipal school of the district (verbal information) when he commented on the projects already carried out by the school. In one of the projects, a science teacher took some students to these ruins, but the project didn't last long and didn't have a deeper investigation into it.

Therefore, we had the idea of starting a more in-depth investigation about this plant, due to its historical relevance to the city of Ilhéus and the potential for teaching physics and technology from the theme of electricity generation. We planned the investigation initially by consulting historians from UESC (State University of Santa Cruz) who work with regional issues, and then we made visits to the sites, researched historical documents and interviews with people who had some relationship with the plant. With some research material in hand, we thought of extracting information that could be addressed in physics classes in the 4th cycle of elementary school at the Castelo Novo school. With this, we also intend to contribute to the construction of science teaching projects in other locations.

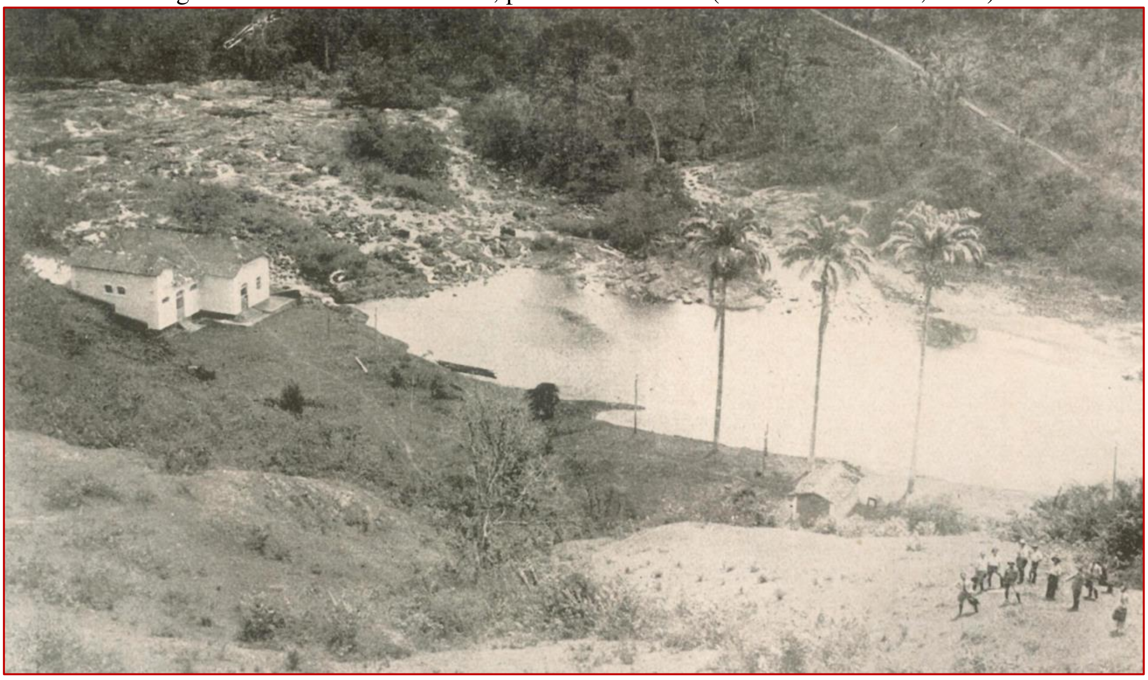
Figure 1: View of the ruins of the Almada Power Plant in Castelo Novo (Author's collection)

THE ALMADA POWER PLANT

The Almada Power Plant (Figure 2) was built in the city of Ilhéus, located in the southern region of the state of Bahia, 458km from the capital Salvador. Dom João III donated a large portion of land to Jorge de Figueiredo Correia, which allowed the installation of the hereditary captaincy of Ilhéus in 1535. In 1556 the village of São Jorge dos Ilhéus was founded, which became a producer of sugar cane. In the eighteenth century, cocoa seedlings imported from the Amazon adapted perfectly to the region. In this way, a time of great riches began in the region with the cultivation of the "golden fruit" (CAMPOS, 2006).

São Jorge dos Ilhéus was elevated to the category of city on June 28, 1881, due to its great commercial importance at the time (Campos, 2006, p.404). Between approximately 1874 and 1883, Ilhéus already had cocoa as its main source of wealth (Campos, 2006, p.406). The "golden fruit", as it was known, was the main driver of the wealth generated in Ilhéus until the appearance of the witch's broom in the 1980s. The profits generated by the cocoa plantation were very large, causing huge fortunes to emerge among the most traditional families in the city. Just as the profits were large, so was the collection of taxes by the municipality. In this way, the city's intendants were able to make relevant investments in urbanization works in Ilhéus, which was known as the "Little Princess of the South" of Bahia.

Figure 2 – Photo: Almada Plant, published in 1938. (Source: BONDAR, 1938)



Public lighting was inaugurated in Ilhéus in 1890 by means of kerosene luminaires. On the last day of 1910, the city experienced public lighting by burning acetylene gas (CAMPOS, 2006, p.499). Ilhéus became aware of electric public lighting on March 2, 1916 (CAMPOS, 2006, p. 535) possibly this lighting did not yet come from a source generated by the waterway, since the concession for the operation of the Almada Power Plant, also known at the time as the Itaípe Power Plant[2], was given on July 15, 1916 to the Light and Power Company (BAHIA, 1920).

At the turn of the nineteenth century to the twentieth century, there were some initiatives in Brazil, mainly in the states of São Paulo, Minas Gerais and Rio de Janeiro (Serrano, 1999, p. 7) for electricity generation. These initiatives, according to Serrano, were promoted "(...) by entrepreneurs whose agricultural, commercial, industrial or financial activities were linked to the localities to be benefited by the new services." (SERRANO, 1999, p. 7)

We heard about the electricity generating plant as a thermoelectric plant built in the city of Campos, Rio de Janeiro, in 1883, powered by English coal (BRASIL, 1977, p.34). This city was the first in Brazil to receive public lighting by means of a thermoelectric plant, which operated with 3 dynamos of 52 KW to light 32 lamps of 2000W (BRASIL, 1977, p.54). Before that, Emperor D. Pedro II had inaugurated in what is now the Central do Brasil, in the city of Rio de Janeiro, in 1879, public lighting by means of six *Jablockhoff-type* arc lamps, which replaced 46 gas nozzles and produced better luminosity. It was in the same year, 1879, that Thomas Edison built the world's first power plant, intended for public lighting in New York City (BRASIL, 1977, p. 53 and 54).

The first hydroelectric plant was built in 1883 in the city of Diamantina – MG for private use. In 1889, the first hydroelectric power plant was inaugurated in Juiz de Fora, Minas Gerais, to supply electricity to an industry (textile) and to public lighting. In Bahia, the first hydroelectric plants were the Jaguaripe River power plant in the city of Nazareth, founded in 1906 to supply the city and for private use; the Bananeiras Plant on the Paraguaçu River, founded in 1906 and located in the Bahian Recôncavo to supply the city of Salvador and region, founded in 1907; the Una River Plant in Valença, founded in 1907 to supply the city and an industry, and the Almada Power Plant, founded in 1916 to supply the cities of Ilhéus and Itabuna and two smaller villages near Almada (BAHIA, 1920).

[2] Itaípe was the name given at the time to the non-navigable part of the Almada River, which ended exactly where the plant was located. Today the entire river is known as Almada, and the name Itaípe has fallen into disuse.

We can say, then, that the Almada Plant was a pioneer among the initiatives of electricity generation in Bahia by hydropower. For some time, there had been thinking about electric lighting in Ilhéus, since in 1905, Manoel Silva Santos obtained a forty-year concession to exploit electricity in Ilhéus, taking advantage of its hydroelectric potential (CAMPOS, 2006, p.464). At that time, there were no public policies for electricity service, as well as no specific legislation. Thus, the concessions for the generation and distribution of electricity were carried out through contracts between the government and the private sector (SERRANO, 1999, p.7). The Bahian Constitution of 1891, revised in 1915, assigned to the municipalities the responsibility of legislating on the supply of electricity, as well as bearing the expenses (BAHIA, 1915).

In the specific case of Ilhéus, the *Company of Light and Strength was founded*, headquartered in Salvador (MELLO, 1927, p.20). This company was a corporation that was created from a contract signed in May 1911 between the intendence of Ilhéus and an engineer named Evandro Pinho for the construction of the hydroelectric plant on the Almada River (CAMPOS, 2006, p.500). This company was linked to the company Magalhães & Cia (MELLO, 1927, p.20).

We have not been able to find documents on the date of the plant's closure. Through information from people who lived at the time (verbal information), we deduce that it could have been in a period between the early and mid-1960s. People who worked at the plant informed us that the flow of water from the Almada River was no longer large enough to move the three generators at maximum operating capacity. At that time, Ilhéus also had another plant, which produced electricity from the combustion of diesel oil. In 1962, the Funnel Plant was inaugurated in the city of Ubaitaba (BRAZIL), located approximately 80km from Ilhéus. This plant generates 30MW of power and was large compared to the Almada Power Plant.

At that time, Brazilian legislation was changing. The State began to control the production and distribution of energy, with the establishment of specific legislation, culminating in the creation of Eletrobrás in 1960 (SERRANO, 1999, p.8). Thus, in 1967, after being controlled by CERC (Companhia de Eletricidade do Rio de Contas), the responsibility for the generation and distribution of electricity in the region to which the city of Ilhéus belongs passed to the newly created (1960) COELBA (Electricity Company of the State of Bahia) (COELBA, 1997).

CONTENTS OF PHYSICS AND TECHNOLOGY: STRATEGIES BASED ON THE HISTORY OF THE ALMADA POWER PLANT

The information contained in this paragraph is the result of research in historical documents or through interviews with people who lived at the time when the plant operated. Among these people, two were workers at the plant, one of them a wire guard (responsible for the maintenance of the transmission lines in the Castelo Novo region) and the other was a machine operator (a worker who took care of the generators inside the plant). The third person who collaborated with us was the head of the Almada train station. She is knowledgeable about the region, as she worked and lived near the plant. We will call these people by the names of their professions for the preservation of their identities.

We tried to cross-reference the information provided by the interviewees in order to establish a criterion of reliability necessary to raise the story told orally. We then proceeded with the release of the information that was confirmed by at least two of the three people. Some information could not be confirmed by the train line worker, because he was not aware of some technical data, because it was not a particular aspect of his profession.

Moreover, we subject the speech of our sources to the examination of physics itself. For example, when two people told us that generators trip when a wire broke, we can deduce that this is true due to the fact that generators no longer encounter much resistance to rotation, due to the end of the counter-electromotive force present while the circuit is closed (verbal information). With the increase in rotation, the machines triggered a protection mechanism that turned them off, avoiding damage caused by the high rotation imposed by the low resistance.

We will continue with some information about the plant, and later we will point out in the language used its connections with physics and with aspects of technology, giving suggestions for approaching the contents in the classroom.

The plant was built on the Almada Farm. The plant was located in a 240m2 building, which had 12 lightning rods. Inside this building were three horizontal-axis turbines with 300Hp each, 750rpm rotation with consumption of 1,150m3 of water per second. The alternators were from the German brand *Siemens-Schuckertwerke*, with output voltage of 3000V and nominal power of 250kW, rotation of 750rpm and current oscillation of 50Hz. The excitation of the generators was done by means of 65V direct current dynamos (Figure 3) (BAHIA, 1920).

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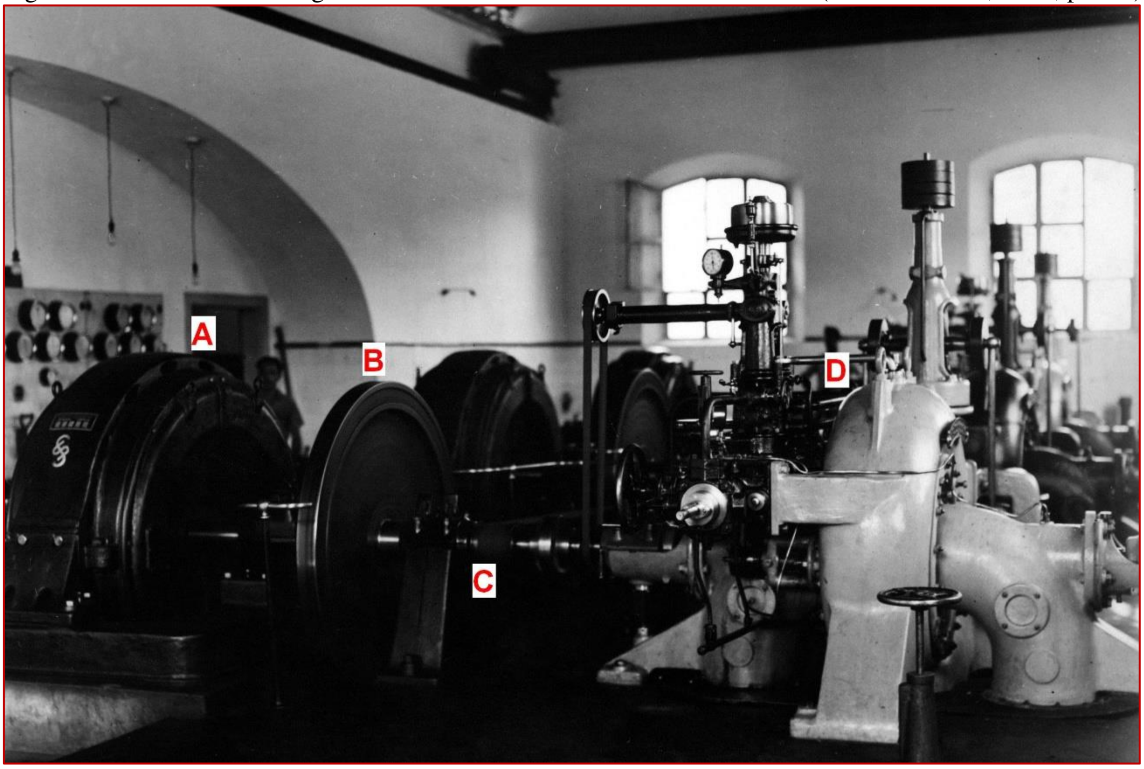
Figure 3 – View of the three generators of the Almada Power Plant in 1942. (Source: SOUB, 2005, p. 161)



In figure 3 we can see some measuring clocks on the left, referring to safety, measurement and regularization devices. Behind this wall with the clocks were the three-phase, oil-lubricated power transformers, which raised the voltage generated from 3300V to 21500V for distribution (BAHIA, 1920). Returning to figures 1 and 2, we can see that the plant building was basically divided into two parts. On the right side were the generators, and on the left side were the transformers in a larger room and the fuses in another room.

Also in Figure 3 we see that generators had four main components. Let's name them according to what was indicated in the photo of the said figure: (A) alternator, where the rotation was transformed into electricity; (B) Flywheel, to give stability to the rotation of the machine; (C) shaft, which transmitted the rotational motion of the turbine to the dynamo and (D) turbine, where the energy of the water is transformed into rotation for the shaft.

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Figure 4: On the left view of the Almada Plant dam on the Bonfim Farm and on the right photo of the stone channel on the same farm. The plant's water flow was manually controlled by gear-operated gates.

The water dam (Figure 4) was located on another farm, Fazenda Bonfim, located approximately 1500m upstream. The water came through an 800m long stream, artificially built and dividing the riverbed forming an artificial island known as *Cocoa Island.* Then the water entered a stone and concrete channel 2m wide, 1.5m high and 1300m long, and then, 130m from the plant, it was channeled into metal pipes of 1.3m in diameter. The slope from the dam to the plant is 0.001 per meter and the water discharge was 5.3 m3 per second (BAHIA, 1920). In the basement of the plant, the water was divided into three smaller pipes to feed the generators (verbal information).

In the right part of Figure 4 we see a man next to a kind of gate. At that point was one of the plant's sluices, where specialized people controlled the flow of water. Many of these locks, some smaller, spread across the canal. At the entrance of the metal pipe to the plant there was also a valve to contain the water. People had to stop the flow of water manually if the generators stopped working due to a malfunction or a disruption in the network due to a broken wire, for example. It was common when there was a need to contain the water, one of the machine operators or assistants would run to close the valve at the entrance of the plant, then send a warning to stop the flow of water along the canal to the dam. In the dam there was the resource of diverting the water so that it flowed only in the riverbed (verbal information).

The transmission lines were 32 km long to Ilhéus and 28 km to Itabuna. The wires were suspended from wooden poles spaced 60m apart. There were two substations with transformers to reduce the voltage from 21500V to 3300V again. These substations operated with 170kW transformers, with distribution made in five 220V circuits (BAHIA, 1920).

Some interesting information given by the wire keeper refers to safety aspects of the plant. He said that a person once passed away due to the fact that he made a mistake by misplugging a switch after cleaning the "copper bars," which made the fuses. The wire guard said there was no protective gear at the time. He also commented that another person died while doing maintenance on the plant's lightning rod, which burned out after an electrical discharge. The person was not wearing protective gear and fell from the lightning rod. The wire keeper commented on a strong flood in 1947, leaving the localities dependent on electricity from the Almada Power Plant unsupplied for six months. In the ruins of the plant we can still see a mark made at mid-height of the wall of the building, showing where the water from this flood reached (verbal information).

In view of this information, we prepared a table with the main concepts to be addressed in science classes about the phenomena and situations described in the reports of our interviewees and in the documents researched:

Chart 1 - Suggestion of physics concepts that can be worked on from the study of the Almada power plant

Situation described	Related physical or technological concept
Distance from the dam to the power plant and height of the dam relative to the power plant.	Total slope calculation. Conservation of mechanical energy and transformation of the translational energy of water into turbine rotation energy.
The turbine.	Energy Transformation
The Generator	Energy conservation. Rated power and output power. Yield.
A roda de inércia.	Rotational inertia and its role in the stability of movements
Or alternator.	Transformation of mechanical energy into electrical energy; Electromagnetic induction; Power; Rotation frequency and current oscillation.
Shutdown of generators	Counter-electromotive force and safety measures.
Alternator output voltage.	Ratio of the output voltage to the electric current and power of the generators.
Output voltage of transformers.	Electromagnetic induction applied to transformers; Transmission technology by voltage elevation (transformation of electrical energy into thermal energy in conductors); Transformer lubrication technology.
Aspects of light bulbs at the time.	Explore technical answers about the fact that the power is not sufficient and does not reach certain locations.

Voltage transformer stations in cities.	Electricity transmission technology.
River flow and power supply.	Power Plant Electricity Generation Capacity
Safety equipment, fuses and lightning rods.	Electrical insulators, safety procedures when handling electricity; Fuse concept; Lightning rod concept; Investigation into which would be the measuring clocks mentioned in the text.
Power outages and preventive measures	Planning and strategies for electricity supply.

SOME ASPECTS OF THE STS (SCIENCE, TECHNOLOGY AND SOCIETY) APPROACH TO SUPPORT CLASSROOM WORK

In this section we will raise some aspects that we consider relevant of the STS (Science, Technology and Society) approach, in order to support objectives and strategies for a possible use in the classroom of our historical study of electricity production in the district of Castelo Novo in Ilhéus.

Vieira and Vieira relate an orientation in STS as a goal of scientific literacy, so that students can obtain a good base of scientific knowledge aiming at the "(...) development of responsible citizenship, within the scope of personal and social skills that enable citizens to deal with problems of a scientific and technological aspect". (VIEIRA and VIEIRA, 2005, p. 192)

The authors point out that a STS approach should aim at the study of science around context, enabling the acquisition of scientific knowledge and the development of cognitive capacities and attitudes to cope with real problems, that is, social problems involving science and technology that can be useful in everyday life from an action perspective (VIEIRA and VIEIRA, 2005, p. 193).

Santos and Mortimer also point out the evidence of the influence of science and technology in our lives, but criticize the overvaluation of science as a means of *saving humanity*, the idea of neutrality of science and its consequences for the school curriculum due to the experience of the "scientific method" by *mini-scientists*, and scientism as an ideology of domination that emerged with the development of capitalism, due to the impositions of the system by consumption often dictated by the needs of production and not by subsistence. Following this reasoning, the authors defend the production of knowledge through the interaction between various segments of society, such as scientists, representatives of governments, the productive sector, non-governmental organizations and the media (SANTOS and MORTIMER, 2000).

According to the authors, citing ROBERTS, a curriculum with an emphasis on STS has as its fundamental principle science in the social context, dealing with the relations between the explanation given by science, the technological program and the solution of practical problems of social importance (ROBERTS, 1991, *apud* SANTOS and MORTIMER, 2000, p. 3). Citing several authors, Santos and Mortimer refer to the main objective of teaching STS education in high school as related to "(...) scientific and technological literacy of citizens, helping the student to build knowledge, skills and values necessary to make responsible decisions on science and technology issues in society and to act in the solution of such issues." (SANTOS and MORTIMER, 2000, p. 4).

Santos and Mortimer thus present a suggestion for working with STS contents, such as the development of values linked to collective interests,

> "(...) such as those of solidarity, fraternity, awareness of social commitment, reciprocity, respect for others and generosity. Such values are thus related to human needs, which means a questioning of the capitalist order, in which economic values impose themselves on others." (SANTOS and MORTIMER, 2000, p. 5)

In its conceptual structure, Santos and Mortimer, citing BYBEE (BYBEE, 1987, *apud* SANTOS and MORTIMER, 2000, p. 5), work with the idea that it would be composed of themes related *to* scientific and technological concepts, research processes and interactions between science, technology and society. Thus, they emphasize the presentation of science in a critical way, seeking to dispel the myth of scientism that helped to consolidate the submission of science to market interests. Citing CHALMERS, they mention the presentation of science as an open activity, under continuous construction and closed by certain limits, emphasizing the need to discuss its social and political dimensions (SANTOS and MORTIMER, 2000, p. 5-6)

As for technology, the authors say that it can be understood as knowledge that allows us to change the world, definitively associated with scientific knowledge as an applied science. But, citing VARGAS (VARGAS, 1994, *apud* SANTOS and MORTIMER, 2000, p. 7), they mention that technology consists of a combination of human activities associated with symbols, systems, instruments and machines aimed at the realization of works through systematized knowledge. It is necessary to identify technology not only for its technical aspects, but also for organizational, cultural, socio-political and value issues, so that citizens can perceive the role of technology in their lives and how it can interfere (SANTOS and MORTIMER, 2000, p.7).

On the social issue, several authors are cited who approach STS contents as articulators of scientific or technological themes *that are potentially problematic from a social point of view*. Expressing RAMSEY's ideas (RAMSEY, 1993 *apud* SANTOS and MORTIMER, 2000, p. 9), the authors comment that the origin of a social theme in the STS approach must originate in activities related to science and technology, with different possibilities of problems associated with *different sets of beliefs and values* (SANTOS and MORTIMER, 2000, p.9). In this aspect, they highlight the essay of the role of students as citizens and their influence as such, so that they are stimulated to participate in society democratically through the expression of their opinions.

Citing AIKENHEAD, Santos and Mortimer suggest the approach in STS from a problem of social origin, followed by an analysis of the technology associated with this problem, a study of the scientific content as a function of the technology and the social theme, the study of technology as a function of the content and the discussion of the original social issue (AINEHEAD, 1994a, *apud* SANTOS and MORTIMER, 2000, p.12)

THE PCN (NATIONAL CURRICULUM PARAMETERS) IN SCIENCE CLASSES FOR THE TEACHING OF PHYSICS FROM A REGIONAL HISTORY PERSPECTIVE

We will now continue what we have raised about the STS approach to inform actions in the classroom. We will not give exact suggestions on how to work on the suggested contents, such as exactly what text to use for reading or what experiment to do with the students, because we choose to leave the teachers free to think about how to work on a theme related to regional history. However, we would like to point out some more possible strategies in general, as well as some more possibilities for the relationship between physics and other areas of knowledge. To this end, we rely on the National Curriculum Parameters (PCN) (BRASIL, 1998) for Natural Sciences in the final years of elementary school.

Firstly, we will mention the importance of students engaging in processes of investigation of themes through teaching strategies, such as experimentation, games and texts, for example, creating an atmosphere of debate and exchange of information in the construction of knowledge, placing the student as the subject of their learning.

> "To say that the student is the subject of his learning means to affirm that it is his movement to re-signify the world, that is, to construct explanations, mediated by the interaction with the teacher and other students and by the cultural instruments of scientific knowledge. But this movement is not spontaneous; it is built with the fundamental intervention of the teacher." (BRASIL, 1998, p.28)

In the chapter on the selection of natural sciences and technology contents, the PCNs reinforce the need to bring them closer to the student's understanding, "*favoring their personal process of constitution of scientific knowledge and other skills necessary for citizenship"* (BRASIL, 1998, p.35). The PCNs then suggest criteria for selecting the contents to provide a vision of a world in constant transformation, with many related elements from a social, scientific, technological, and cultural point of view, thus overcoming naïve interpretations of the reality around them (BRASIL, 1998, p.35).

The teacher can give up strategies for investigating concepts raised by the interviews, choosing with his students a subject that is more relevant and arouses greater curiosity, such as, for example, why the generators stop when a wire in the network broke, or even more than one subject. From there, experiments, readings, new interviews with community residents or former workers of the plant can be planned, as well as field work, for example, to obtain new information, always with the participation of the students and the leadership of the teacher in the choice of strategies aimed at improving learning conditions (BRASIL, 1998, p. 115-116).

Regarding the relationship of the theme with other areas of knowledge, we would like to highlight, in addition to political, economic, geographical, and regional history and cultural aspects, its relations with technology, with the history of science, and with mathematics. According to the PCN, aspects of the history of science and the history of inventions can contribute to the debate on the relations between science, technology and society and draw attention to the characteristics of the nature of science (BRASIL, 1998, p. 60). Even so, students can identify different technologies, recent or old, about the energy transformations necessary to obtain electricity (BRASIL, 1998, p. 78)

Relationships can be established in a joint work with the area of mathematics through experimental or field activities for the construction of knowledge about measurements (BRASIL, 1998, p.123), quantities and units involved, measurement instruments and systematization of results in graphs and tables (BRASIL, 1998, p. 79-80).

CONCLUSION

In this work, we emphasize the survey of physics and technology contents based on a regional historical theme: the production of electricity in Ilhéus from the 1910s onwards. Although this theme is very relevant for the region of Ilhéus and its residents, it can also be worked on in schools in other locations because it addresses general aspects of the importance that the electricity sector has for our economy. In addition, historical information on its evolution can be useful in the study of what would be a strategic planning for the supply of electricity and its relations with the development of citizenship. Another way for schools to take advantage of this work would be to raise issues within the region where it is located for the teaching of physics, technology and other sciences. Preliminary research shows that this type of work has been well accepted by teachers and students, motivating the study and teaching of physics (STUCHI and BEJARANO, 2009).

In this sense, we consider it important that a teaching strategy with the theme proposed here takes into account studies based on the STS movement. Therefore, according to our citations in this text, the teaching of science should be of great social relevance for students and teachers, based on the formation of capable citizens who can participate democratically in society through the acquisition of knowledge and the formation of opinion, by the vision of technology not merely as a product of science and of science itself as a human construction, error-prone. Thus, teachers should keep in mind the importance of scientific literacy of their students, aiming at the acquisition of skills and values necessary for responsible decision-making and attitudes regarding issues involving science, technology and society. For the lives of Castelo Novo students in particular, these attitudes and decisions may have an important tendency towards the preservation of the history and memory of their community and their city.

With the citation of the PCN, we try to suggest ways for teachers to deal with students, emphasizing the importance of the topics studied being addressed in a participatory way, by debating the issues raised and by the diversity of teaching and assessment tools, thus trying to make the content more interesting and meaningful. In this way, we hope that we have also contributed to the formation of a teaching strategy in line with the official national documents.

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