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The manufacture of printed circuit boards and the teaching of chemistry under a CTSA approach

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ABSTRACT
The contextualization of experimental activities based on the inclusion of the students' daily lives, and of CTSA contents provide a broader view of chemical phenomena, resignifying the role of the school to society, giving meaning to experimental activities and scientific contents, contributing to the learning of scientific contents and to the citizenship training of students. Therefore, this article aims to present an activity for the teaching of oxidation reduction reactions under a CTSA approach with the theme Printed Circuit Boards (PCI). That is, the students built a PCB and CTSA content about the extraction of metals and the disposal of electronic equipment was built with them. This activity was part of the teaching project: "Experimental activities: science and technology in everyday life" developed at IFPR - Barracão Campus.

Keywords: CTSA (Science, Technology, Society and Environment), Printed circuit boards (PCB), Oxyreduction reactions, Science teaching, Science education.

INTRODUCTION

Printed circuit boards (PCB) are like the skeleton of an electronic device, that is, they serve as the base where parts (electronic components such as: chips, resistors, capacitors, etc.) are assembled and connected. They are made of an insulating material, covered by layers of copper that form the "pathways" through which electricity flows. PCBs facilitate the connection between internal components and make devices more compact, and because of their "simplicity" they facilitate the production of electronics on a large scale.

The manufacture of these plates involves an oxidation-reduction reaction, in order to corrode the excess copper of the plate, leaving only the tracks belonging to the elaborate circuit, for later connection of the desired elements.

PCBs are used in electronic equipment, for example: cell phones and computers, so they are widely present in our daily lives, and their composition is varied, with metals such as gold, aluminum, copper, lead, nickel, tin, palladium, silver and zinc detected in discarded computer boards analyzed by Ribeiro (2013).

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According to Aikenhead (2009), CTSA teaching has as its proposal the integration of canonical knowledge of science and the student's daily life, as a subsidy for students to understand their daily world, starting from their reality and their knowledge and considering the student protagonism in the teaching-learning process, therefore, the process is centered on the student and not on science.

Acevedo-Díaz (1997) points out the different objectives of CTSA education in the formation of citizens: a) to help in the understanding of scientific and technological knowledge, its relations and differences, as well as to attract students to professional careers related to the areas of science and technology; b) understand scientific and technological development in its historical and social context; c) understand the social and environmental impacts resulting from scientific and technological development, allowing their participation in society for decision-making. The author emphasizes the third objective as the most important for basic education.

From this perspective, the CTSA education approach aims at the interaction between scientific, technological and social education, in which historical, ethical, political and social, environmental discussions are articulated with scientific and technological contents, allowing the understanding of how the development of science and technology depends and implies on political and economic interests, values and ideologies of society and on the environment in which we live. building knowledge for life. (SANTOS, 2007).

In practice, CTSA education presents a didactic structure contextualized and developed in dialogic classes, in which the student is active in the teaching-learning process, either through experiments or through other activities that stimulate their participation in the organization of knowledge.

This article presents a proposal for the teaching of the oxidation reduction content from the realization of a thematic experimental activity under the Science, Technology, Society and Environment (CTSA) approach. This class model was developed during the execution of the teaching project: Experimental activities: science and technology in everyday life; during the year 2023 with students from the Integrated Technical Courses in Administration and Informatics at IFPR- Advanced Campus Barracão.

The BNCC (2018) presents the Transversal Contemporary Themes (TCTs) as potential for the integration of contents, being able to equip students for a greater understanding of the society in which they live. Thus, the choice of the theme "Science and technology" is in line with the present didactic proposal, which, from the PCI context, aimed to articulate chemistry contents and the interrelations between the scientific knowledge addressed and technological, social and environmental issues involved in the manufacture of PCI boards, that is, integrating the canonical scientific content and the CTS content, producing the scientific content CTS according to Aikenhead (2009).

Silva and Marcondes (2011) present a structural model of a contextualized didactic unit, in which questions such as: what is it? What are the causes and consequences? They guide to an overview of the problem, facilitating the contextualization of the content to be studied, emphasizing the importance of language close to the student's language, so that scientific language can later be introduced. Chemical concepts are introduced through activities involving different strategies for the development of scientific knowledge, such as experiments, lectures, lectures, reading of scientific texts, etc. The student's language is transformed, and the teacher synthesizes the knowledge approached, weaving the relationships between them, which will facilitate the expansion of the student's vision. and subsidizing their intervention in society (SILVA and MARCONDES, 2011). Corroborating the aforementioned authors, Aikenhead (2009) considers that for students' learning, they become better critical, communicative, creative in problem solving and capable of making decisions in a daily context related to science, with greater social responsibility.

Thus, considering the great interest of students in experimental classes and their potential for the construction of scientific knowledge in a significant way when developed in a contextualized way and that stimulate communication, collaborative work, reflection-action; This didactic proposal sought to overcome experimental practices of technical repetition, which contribute little to student learning.

Diversifying the learning contents, stimulating the critical participation of students and raising issues of social interest, in addition to ensuring that the student moves between the three levels of chemical knowledge: macroscopic observation, microscopic interpretation and representational expression, we believe in the potential of this didactic proposal to contribute to the students' learning, leading them to reflect on problems related to the theme addressed. evaluate possibilities and make decisions in a critical and scientifically grounded way at school and in life.

MATERIALS AND METHODS

TITLE OF THE DIDACTIC PROPOSAL: METALS AND THE MANUFACTURE OF COMPUTERS; PRODUCTION OF PRINTED CIRCUIT BOARDS.

The thematic experimental activity under the CTSA approach presented was developed during the execution of the teaching project: Experimental activities: science and technology in everyday life; which had two scholarship students, during the year 2023 with students from the Integrated Technical Courses in Administration and Informatics of the IFPR - Advanced Campus Barracão.

The activity lasted 3 hours and was carried out in a classroom adapted for the activity on campus, in the students' after-school hours, with voluntary adherence.

This proposal is based on the BNCC (2018, p.472):

> [...] learning of scientific and technological processes, practices and procedures, and promotes the mastery of specific languages, which allows students to analyze phenomena and processes, using models and making predictions[...] broaden their understanding of life, our planet and the universe,

> as well as their ability to reflect, argue, propose solutions and face personal and collective, local and global challenges;

And it is structured under the Guiding Principles of the General National Curriculum Guidelines for Professional and Technological Education (2021, p.02) such as:

> VI - technology, as an expression of the different forms of application of the scientific bases, as a guiding thread of the essential knowledge for the performance of different functions in the productive sector;
> VII - inseparability between education and social practice, as well as between knowledge and practices in the teaching and learning process, considering the historicity of knowledge, valuing the subjects of the process and the active and innovative learning methodologies centered on students;

Objectives:

- To produce a printed circuit board with the assembly of a simple circuit;
- Understand the chemical composition of PCBs and their applications;
- Relate social, environmental and economic issues involved in the process of extracting metals;
- Recognize the importance of the correct disposal and recycling of electrical and electronic materials and understand the concept of urban mining and its socio-environmental impacts;
- Understand, based on the NOX change of the atoms of the substances participating in the PCI corrosion reaction, the occurrence of an oxidation-reduction reaction;
- Encourage collaborative work, self-care and care for others during an experimental activity;
- Reflect and argue about the PCB production process.

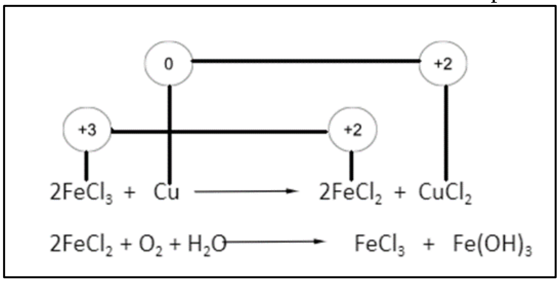
DEVELOPMENT OF THE DIDACTIC PROPOSAL

First, the students were invited to reflect on the following questions: 1- What electronics do you have in your home? 2- Do you know what they are made of? After the initial dialogic approach with the students, the analysis of two images was proposed – a land impacted by mining and people collecting materials in a dump – and question 3 – Can you identify the relationship between the images and the electronic equipment you use?

Then, a presentation was made on some metals that make up a PCB, addressing their properties and applications. The students were shown the video "Congo: Trapped in the Mud | Mortal Journey" on YouTube, and reflections on working conditions in the mines, as well, with the presentation of a report on the accident at the copper mine in Chile in 2010 and a brief history of mining in Brazil.

Next, we highlight the concept of urban mining and its importance for the metal recycling chain, in contrast to the risks of the work of waste pickers in dumps. Next, the concepts of PCI and its production from the reaction between the copper of the plate with the iron perchloride and the reaction of reconstitution of the iron perchloride after agitation of the solution were exposed, which are shown in Figure 1.

Figure 1 - Oxidation-reduction reaction that occurs in the production of PCI



Then, the practice script was delivered, showing which equipment and reagents will be used and the precautions to be taken during the experimental procedure.

The iron perchloride solution can be reused several times, however, each time it is reused, the solution will become "weaker" and weaker, so the time to corrode the copper will be longer. Do not use metal objects to stir the mixture. For this purpose, use plastic or glass sticks. The solubilization of salt in water is exothermic.

Practice roadmap

Attention! Iron perchloride solution has the potential to stain clothing, so handle with care and use Personal Protective Equipment (PPE).

Materials:
1 phenolite plate
1 led
paper
Iron perchloride solution (FeCl3) 0.4g/mL
Petri dish
1 resistor
Gloves
2 batteries
Mask
String, adhesive tape
Safety glasses
Solder
Drill with 1 mm bit
Pen
Steel wool with detergent
Beaker with water

Procedures:

Step 1: Put on PPE.

Step 2: Clean the plate (copper-plated side) with the steel wool and detergent to remove fingerprints and possible dirt and dry with paper.

Step 3: Make the drawing of the circuit on the board with the pen using the template at the end of the script.

Step 4: Place the string on the tip of the dish and dip it into the FeCl3 solution placed in the petri dish. Leave until the copper is corroded (about 15 min).

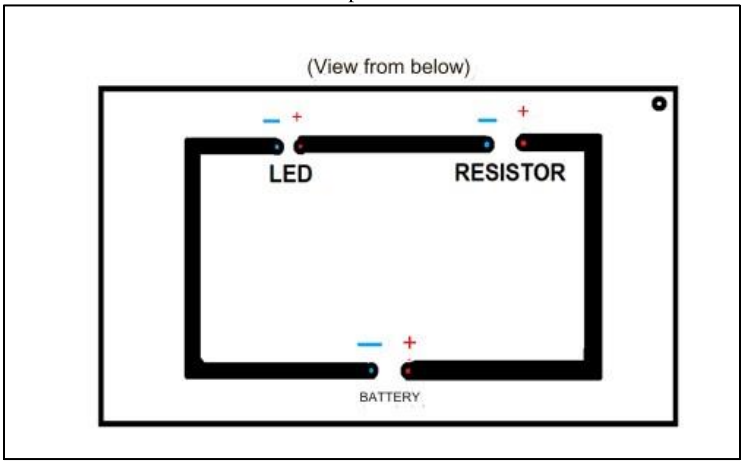
Step 5: Rinse the plates in the beaker with water and dry. Clean the pen drawing with paper and alcohol.

Step 6: Drill the connection points of the circuit elements.

Step 7: Assemble the components according to the representation and weld them

Step 8: Connect the batteries according to the model (attach the batteries with a tape).

Trail template for PCI.



After the experimental practice, the students were asked by the monitors (scholarship students of the project) about the importance of the corrosion reaction (oxidation-reduction) of the plate for its proper functioning, and a reflection on the property of metals to conduct electric current was conducted.

RESULTS

It was observed that the students felt involved by the initial questions (What electronics do you have in your residence? Do you know what they're made of? Can you identify the relationship between the images and the electronic equipment you use?), and did not know how to relate the image of the mine with the electronic equipment, relating only the image of the dump with consumerism and the rapid evolution of technology and disposability of electronic products, revealing one more path to be followed from this didactic proposal, involving consumerism, planned obsolescence, advertising and marketing, overcrowding of landfills, among others. Thus, the reflections

They were oriented to the issue of extraction of raw materials and their socio-environmental impacts and recycling as a way to generate income and reduce environmental and social impacts in mining.

The participation of the students in the discussion about the importance of the corrosion reaction (oxidation-reduction) of the plate for its proper functioning demonstrated an understanding of the process that occurred and its importance of conducting electric current and the functioning of the plate.

Therefore, the direction of questions in a practical activity instigates argumentation and investigation, in addition to observation and purely empirical reporting, and is fundamental for understanding the theoretical-practical relationship within the students' social context. That is, experimentation allows the learning of something complex to become interesting and easier to understand through active learning.

Figure 2. Students participating in the PCI construction activity.

The CTSA approach in school activities is strengthened when worked together with activities in which students participate and exercise argumentation and critical thinking, as it allows students to develop skills for decision-making in the face of everyday issues involving science and technology. Thus, the teaching of chemistry under the CTSA approach combined with experimentation developed in a dialogical way subsidizes the construction and connection between canonical knowledge and social, environmental and technological issues, in the social context of the students.

FINAL CONSIDERATIONS

The contextualization of experimental activities based on the inclusion of students' daily lives, and CTSA contents provide a broader view of chemical phenomena, resignifying the role of the school for society, giving meaning to experimental activities and scientific contents, contributing to the learning of scientific content and to the citizenship formation of students.

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