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WIND ENERGY AND ENVIRONMENTAL AWARENESS IN TEACHING ELECTRODYNAMICS

Energia eólica e conscientização ambiental no ensino da eletrodinâmica

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Abstract
Teaching integrated with environmental issues has strengthened the cross-cutting nature of different subjects in basic education. Thus, this study aimed to report the results of implementing a teaching sequence focused on teaching/learning electrodynamics, based on the debate about sustainable electricity generation. The teaching sequence involved discussions on the environment, electricity generation, and sustainable development, culminating in the construction of a model composed of lamps, *LEDs,* resistors, motors, and actuators. The proposal was implemented in classes of high school students at a full-time state school. The proposal proved effective, promoting students' understanding of the content and reflection on the topic.

Palavras-chave
ensino conscientizador
eletricidade
sustentabilidade
responsabilidade ambiental

Resumo
O ensino integrado às questões ambientais tem fortalecido o caráter transversal das diferentes disciplinas do ensino básico. Assim, esse trabalho teve como objetivo relatar os resultados da implementação de uma sequência didática, com foco no ensino/aprendizagem de eletrodinâmica, a partir do debate acerca da geração sustentável da eletricidade. A sequência didática envolveu discussões ambientais, geração de eletricidade e desenvolvimento sustentável, culminando com a construção de uma maquete composta por lâmpadas, LEDs, resistores, motores e acionadores. A proposta foi implementada em turmas de estudantes, de ensino médio, de uma escola estadual de tempo integral. A proposta mostrou-se efetiva, favorecendo a compreensão do conteúdo e a reflexão dos estudantes sobre o tema.

Educating for a global understanding of natural processes involves discussing various phenomena within the scope of the natural sciences, each of which challenges concepts, skills, and competencies, thereby promoting effective learning and solving every day and technological

problems (Teixeira, 2019). In this sense, Saldanha (2012) highlights the complexity of environmental issues in their various dimensions. This complexity is often reflected in the classroom, in teaching and learning activities.

The contextualization of energy sustainability and environmental conservation is a fundamental characteristic of science teaching, allowing the concepts studied in physics, biology, and chemistry to be interrelated in different situations. Given current environmental issues, high school education seeks to train individuals capable of interpreting and solving sustainability problems through the appropriate use of concepts and conceptual/technical formalizations, leading not only to an understanding of phenomena, but also to active intervention in specific everyday situations for the good of the planet and collective well-being. Siqueira (2024) highlights that this possibility, in addition to involving skills and competencies that are supplementary to the teaching of physics, reinforces the perception of the discipline as an instrument for interpreting reality, in which mathematical concepts and tools gain material significance in the face of environmental/climate problems.

In this research, a didactic sequence was implemented aiming to bring together current discussions and themes focused on environmental awareness, together with concepts of electrodynamics. The aim was to gather discussions, reflections, and lessons learned by students regarding the generation and distribution of electricity, as well as environmental conservation and sustainable use. The proposal was selected based on the guidelines presented in the Alagoas Full-Time Education Program (Alagoas, 2019), which outlines the teaching and assessment tools to be used by teachers across the different curricular components of the program. Given this context and the organization of teaching and assessment, this study aims to report the results of implementing a teaching sequence focused on the teaching/learning of electrodynamics, based on the debate on sustainable electricity generation with a view to environmental conservation.

This qualitative study describes the implementation of a teaching sequence (Chart 1), which addressed the basic principles of thermodynamics through the themes of energy generation, sustainability, and environmental awareness.

A model was built as an integral learning and assessment tool, utilizing the following electrical materials: 10Ω resistors, 3V blue LEDs, 10Ω bulbs, tin solder, a soldering iron, cutting pliers, a 6V/2A power supply, and electrical tape.

CHART 1 - Teaching sequence developed with the students targeted by the research.

Discussion topic/workload	Development	Learning reinforcement activities	Assessment
The theme chosen by students is based on the LPE guidance document. Two hours/class	Debate in which students are presented with possible topics for study, reflecting on their importance and feasibility.	Voting on the topic, with the theme "Renewable energies and energy sustainability" being chosen.	Observation and socio-interactional analysis of students and encouragement of dialogue.
Types of energy generation: hydroelectric, nuclear, solar, and wind. Environmental Impacts, Advantages, and Disadvantages. Two hours/class	Based on the students' prior knowledge, the problem of electricity generation and its environmental impact was presented.	Students worked in pairs to answer a six-question questionnaire, in which they reported their position based on the knowledge discussed in class and other scientific sources.	Dialogic correction of the questions answered by the students, highlighting their positive and negative points, mistakes, and correct answers.
Study of hydroelectric power generation processes. Two hours/class	The national water potential was highlighted as a motivating factor for discussion. At the same time, points and counterpoints about the construction of hydroelectric plants and their impacts were discussed.	In pairs, students were instructed to present, in writing, the advantages and disadvantages of electricity generation through hydroelectric plants, highlighting when they can be beneficial considering their environmental impacts.	Coherence and conceptual mastery of the issues presented: argumentative ability and organization of ideas.
Study of nuclear processes for generating electricity. Two hours/class	Analysis of the potential, risks, and future demands of nuclear energy. Generation processes, reactors, demand, and technology.	Completion of a six-question questionnaire in pairs, in which students reported their position based on the knowledge discussed in class and other scientific sources.	Dialogic correction of the questions answered by students, highlighting their positive and negative points, mistakes, and correct answers.
Study of solar electricity generation processes. Two hours/class	With the increasing commercialization and popularization of solar energy, its generation process is presented, with special attention to physical aspects, highlighting its potential for environmental preservation.	Group solution of a six-question quiz in which students report their position based on the knowledge discussed in class and other scientific sources.	Dialogic correction of the questions answered by the students, highlighting their positive and negative points, mistakes, and correct answers.

(continues)

Discussion topic/workload	Development	Learning reinforcement activities	Assessment
Study of the wind power generation process. Two hours/class	Wind energy is discussed as a clean and alternative source capable of generating minimal or no impact on the environment. Energy conversion processes are revisited, such as the transformation of kinetic energy into electrical energy.	In pairs, students were instructed to present, in writing, the advantages and disadvantages of generating electricity through hydroelectric power plants, highlighting when these can be beneficial in light of the environmental impacts caused.	Coherence and conceptual mastery of the issues presented: argumentative ability and organization of ideas.
Electric current, voltage, and resistance (Ohm's law). Two hours/class	The concepts of current, voltage, and resistance are presented practically through the manipulation of components.	Solving four problems on Ohm's law, theoretically illustrating the practical aspects reinforced in class related to the assembly of the model.	Active participation of students in assembling the model and assertiveness in solving problems.
Electric circuit of a mesh. Two hours/class	Students were instructed to create a circuit simulating the public electrical grid of a street containing houses, buildings, and a wind power station.	Solving four problems on resistive circuits with a mesh, theoretically illustrating the practical aspects reinforced in class related to model assembly.	Active student participation in assembling the model and assertiveness in solving problems.
Association of resistors. Two hours/class	Students were instructed to connect light bulbs in houses and lampposts, paying attention to the supply voltage to prevent components from burning out.	Solving four problems on series and parallel connection, theoretically illustrating the practical aspects reinforced in class related to the assembly of the model.	Active participation of students in assembling the model and assertiveness in solving problems.
Assembly and completion of the model. Two hours/class	The students independently tested the electrical functioning of the model and were asked to present and discuss its operation, significance, and relationship with the environment and wind energy.	The students were encouraged to work independently to complete the model, its electrical design, aesthetics, and environmental significance, demonstrating the importance of wind energy in everyday life as a clean and renewable option.	The students actively participated in assembling the model and were assertive in solving problems.

Source: prepared by the author (2025).

The proposal was implemented from February to April 2025 in 3rd year high school classes at the José Moacir Teófilo full-time school in Arapiraca, AL, Brazil. The activities were conducted in the Experimental Practices Laboratory (LPE) course and involved 48 students, totaling 20 class hours.

Given the qualitative nature of this research, the analyses and observations made are based on the perceptions of the teacher-researcher who conceived and carried out this work. Thus, it should be noted that the interpretations made are scientific and adhere to the scope of science teaching, even given the intrinsic subjectivity of the interpretative process in question.

In general, the following evaluative aspects were considered during the theoretical classes and activities, recorded to individually assess each student: (1) participation, (2) coherence with the topic studied, (3) social interaction, (4) proactivity, (5) problem-solving skills, (6) manual skills, (7) conceptual and mathematical mastery of the content, (8) organized presentation of ideas, (9) ability to work in a team, (10) ability to interrelate concepts and ideas. The evaluation criteria listed above are derived from the learning objectives initially defined for the LPE.

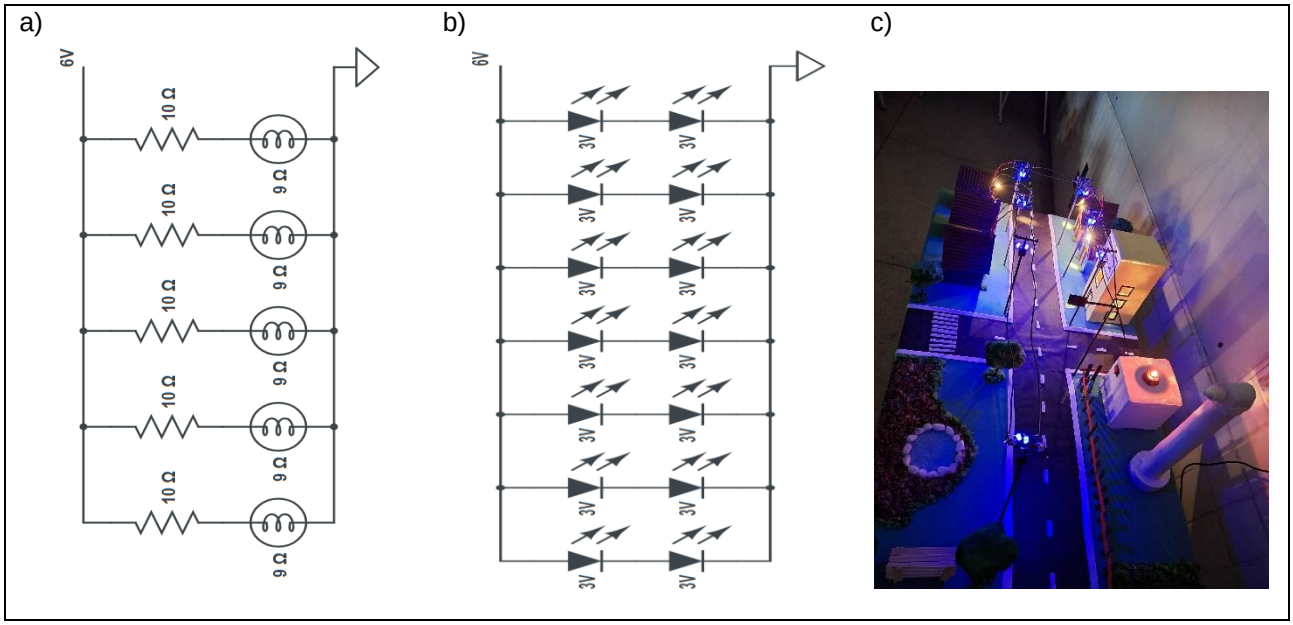
The teaching of physics in high school is not always easy to understand (Barros Filho; Silva, 2002), and it is therefore necessary to seek strategies that motivate students. The dialogic approach used in this proposal (Chart 1), centered on the debate about different forms of energy generation, in addition to the cross-cutting nature of the content, proved to be fundamental, with learning based on reflection and problem solving.

The students built electrical circuits for lighting houses (Figure 1a) and streetlights (Figure 1b), engaging in discussions on sustainable electricity generation. The proposal to build the model (Figure 1c) proved significant in terms of problem-solving for the students, and it is important to highlight its functional aspects, which simulate a small community powered by wind energy.

Based on practical/theoretical activities and assessment tools, it was found that students were able to improve their understanding of the impact caused by different forms of energy generation. Thus, understanding the basics of electrodynamics found a favorable scenario and applicability, with students able to quickly and adequately design and build electrical circuits (Figure 1).

In general, students were receptive to environmental issues, aware of their problems and common aspects, which they mainly acquired from various sources of information, such as television news, social media, and the internet. This prior knowledge served as a starting point for introductory discussions of the content covered in class, while also laying a foundation for new knowledge, refining common sense (correcting beliefs that are at odds with science), and deepening essential questions about energy and the environment.

FIGURE 1 – Home lighting circuit (a), street lighting circuit (b), and finished and functional model (c), made by high school students during the implementation of a teaching sequence.



Source: prepared by the author (2025).

It was found that a significant portion of students initially struggled to remember and deepen their understanding of content already studied, such as the concept of "energy transformation," which is constantly present in electricity generation processes. As Barros Filho and Silva (2002) point out, teaching and learning physics is a challenge in high school. In the present study, this difficulty faced by students reinforces the importance of activities that revisit concepts in an articulated and contextualized manner. In this study, discussions were held not only from a physical, chemical, and environmental perspective, but also from historical and social aspects, which are directly linked to energy generation processes.

It is worth noting that this study employed a qualitative approach to the content, as algebraic treatment was not predominant in the discussions and reflections carried out, given the nature of the content and theme discussed. However, during the assembly phase of the model's electrical circuit, the principles of electrodynamics were explored, reflecting physical laws that can be analyzed mathematically.

After completing the analysis and study of the different energy matrices targeted by the teaching sequence, the students concluded that wind power was the best energy option for the Agreste region of Alagoas. Next, to consolidate the knowledge developed during the process, the students built a model designed to simulate the process of generating electricity from wind power

(Figure 1c). It is essential to note that, to achieve this, the students had to solve the problem of designing and building an electrical circuit for lighting houses and public roads.

Thus, in this stage, the students had to revisit various concepts such as electric current, voltage, and electrical resistance, culminating in Ohm's law. It is essential to emphasize the significance of the teaching sequence proposed in this study for acquiring the knowledge required to assemble lighting circuits (Figure 2). A correct understanding of the concepts led to the proper construction of the circuits, thereby avoiding component damage, waste, and the misuse of materials.

Finally, the students understood the advantages of parallel connection compared to series connection, concluding that the former is more suitable for the continuous and independent operation of the lamps. Upon completing the construction of the model, the students were able to use tools and devices typical of electronics, demonstrating that the activity performed represents a motivating factor for professional practice.

Thus, given the conceptual emphasis and minimum knowledge observed, the students were able to articulate ideas in line with the scientific concepts linked to each energy generation process covered by the teaching sequence. At the same time, they were able to classify these different processes to determine which one is most suitable, given the need to preserve the environment and meet urban demands.

Electrodynamics content becomes more meaningful when linked to motivating topics, broadening students' view of electrical processes and their importance in maintaining the environment.

Based on discussions about electricity generation techniques, students can determine the most suitable form of energy generation, taking into account the geoclimatic characteristics of their region. At the same time, students appropriate the knowledge they have learned by building a lighting circuit on a model.

Given the dialogic approach, centered on the debate about different forms of energy generation, the cross-cutting nature of the content was an important aspect incorporated into teaching practice, valuing economic, social, historical, and contemporary aspects, as well as learning based on reflection and problem solving. The latter gained concrete meaning during the model's construction.

Considering the proximity between school education and professional training, this study points out that the discussion of topics directly related to life and its collective problems, including environmental preservation and sustainable energy generation, tends to stimulate students' reflection on their professional practice in conjunction with good planetary practices, in which certain

professions play a decisive role in maintaining the environment. Thus, the theme of environmental preservation is capable of defining a broad spectrum of discussion in the classroom, going beyond theoretical/practical training to reflection on individual and collective life. Thus, teaching based on environmental issues represents a strong didactic possibility, allowing for greater approximation of content, the development of disruptive learning activities, and debates capable of deepening important issues for collective life and its planetary aspects.

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