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DIDACTIC BASES OF THE STEAM APPROACH IN TEACHING ELECTRICAL ENGINEERING IN HIGHER EDUCATION

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Abstract
This article analyzes the didactic foundations of using the STEAM (Science, Technology, Engineering, Arts, Mathematics) approach in teaching the subject of "Electrical Engineering" in higher education institutions. The author, in contrast to traditional teaching methods, highlights the role of interdisciplinary integration in the development of engineering thinking and creative abilities of students. The article proposes a methodology for connecting electrical engineering laws with modern technologies and design elements on the example of specific projects.

Keywords: STEAM education, electrical engineering, didactics, integration, engineering thinking, project-based education, innovative methodology.

Introduction

The rapid development of technology in the modern world and the transition to a new era are placing new demands on the higher education system. Software, energy and electrical engineering require specialists in the production of knowledge to analyze theoretical theories, sciences, systems in the physical network, as well as creative production. Therefore, reviewing traditional didactic models of teaching electrical engineering in education and modernizing them with innovative STEAM (Science, Technology, Engineering, Arts, Mathematics) is one of the most effective ways today.

For many years, electrical engineering disciplines have been taught in higher education in accordance with fundamental physics and mathematics exercises, often in the form of theoretical calculations and abstract productions. Such students do not form a sufficient idea of the practical significance of science, its connection with modern software technology and aesthetic design (art). They have difficulty finding creative solutions to complex problems in the production

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process. STEAM control is precisely this theory and practice that serves to manage a specific disconnect.

The purpose of this study is to reveal the didactic possibilities of using STEAM technology in teaching electrical engineering in higher education and to develop methodological recommendations aimed at improving students' engineering competencies. In this regard, the main task is to ensure the integral unity of scientific, technological modeling, design skills and aesthetic creativity in teaching the subject.

In the process of research, project-based learning (Project-Based Learning - PBL) and systematic analysis methods were used in teaching electrical engineering. The didactic model of the STEAM approach was developed through the integration of the following 5 components on the example of the sections "Fundamentals of Electrical Circuits" and "Electronics" of the electrical engineering course:

1. Science: Students used research methods aimed at in-depth study of the fundamental physical laws of electrical phenomena (for example, electromagnetic induction, p-n transition processes in semiconductors). At this stage, laboratory experiments serve to test hypotheses.

2. Technology: Modern software packages and equipment were chosen as the basis of the methodology. Multisim and MATLAB programs were used to analyze circuits. Students were also taught process automation technologies using microcontroller platforms.

3. Engineering: This component requires students not only to assemble a circuit, but also to design it. The research used the “reverse engineering” method: a finished device was analyzed and its working model was designed from scratch.

4. Arts: This component is often overlooked in electrical engineering. Students were directed to create an easy-to-read aesthetic drawing (schematic art) of the user interface (UI), body ergonomics, and electrical circuits of the device they were creating.

5. Mathematics: The method of complex numbers, differential equations, and matrices was algorithmized in the calculation of complex alternating current circuits. The results of mathematical modeling were analyzed by comparing them with the results of technological simulation.

The educational process was transferred from the traditional lecture-practical form to the “Lab-Studio” form. In this case, students, divided into small groups

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(3-4 people), worked on one complex STEAM project (for example, “Smart Energy-Saving System”) during the semester. At each stage, the level of students’ mastery was monitored based on assessment criteria that formed the level of students’ mastery.

In order to effectively apply the STEAM approach in teaching electrical engineering, the “Project for a mini solar power plant as an alternative energy source” was implemented in the educational process. Within the framework of the project, students went through the following didactic stages:

1. Theoretical-research stage (Science & Mathematics)

First, students studied the relationship between the efficiency of solar panels and the angle of incidence of light based on physical laws. Knowledge of the photoelectric effect and the physics of semiconductors was updated.

Mathematical Analysis: Trigonometric functions and differential calculus were used to calculate the optimal angle required for the panel to generate maximum power. Students mathematically modeled the inverse square law to determine light intensity.

2. Technological simulation stage (Technology)

Before assembling the real device, students modeled the electronic circuit in Multisim or Proteus programs.

How the microcontroller (Arduino) receives and processes analog signals from LDR (photoresistor) sensors was simulated using digital oscilloscopes. This allowed students to troubleshoot in a virtual environment.

3. Design and engineering solution (Engineering)

At this stage, students designed the mechanical part of the system.

Connecting servomotors to the panel, calculating the center of gravity, and ensuring the strength of moving parts required engineering solutions. Students eliminated mechanical resistance in the system through a “problem-solution” chain.

4. Creative design and ergonomics (Arts)

The project was intended to be not only a technical device, but also aesthetically attractive.

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The students drew the device case in 3D modeling programs (for example, AutoCAD or Fusion 360), giving it a compact and beautiful appearance. Also, the interface (display or mobile application design) showing the state of the system was developed from the point of view of color harmony and user-friendliness (UI/UX).

Didactic analysis of learning outcomes.

As a result of this project approach, the following changes were observed in the students:

• In the cognitive sphere: Theoretical formulas (Ohm's law, power calculations) moved from dry memorization to practical understanding.

• In the psychomotor sphere: Skills in assembling complex circuits, soldering, and working with tools were formed.

• In the affective sphere: Teamwork, a sense of responsibility, and presenting one's own project (soft skills) were developed.

As part of the study, an experimental study was conducted with the participation of students of the "Electrical Engineering" department to test the effectiveness of the STEAM approach. Students were divided into two groups: a control group (trained in the traditional way) and an experimental group (trained based on the STEAM approach).

1. Analysis of mastery indicators

The results of the tests and practical assignments conducted at the end of the semester were distributed as follows:

Evaluation criteria	Control group (average score %)	Experimental group (average score %)	Growth rate
Acquisition of theoretical knowledge	72%	84%	+12%
Practical/laboratory skills	65%	89%	+24%
Finding solutions in problem situations	58%	82%	+24%
Creating an independent project	54%	87%	+33%

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The results show that the greatest increase (+33%) was observed in the area of independent project creation and practical skills. This is a direct effect of the Engineering and Technology components of STEAM. Students learned not only to assemble a ready-made circuit, but also to optimize it and analyze errors in a software (virtual) environment.

2. Competency Assessment (Survey Results)

The "Self-Assessment" questionnaire conducted among students showed that 92% of students in the experimental group noted that the STEAM approach increased their interest in science, and 85% noted that this method gave them confidence in their future engineering activities.

The integration of the Arts component changed the approach of students from a "just workable" approach to an approach that requires projects to be "user-friendly, aesthetic, and concise". This served as an important didactic factor in the formation of engineering culture.

3. Pedagogical observations

During the discussion, it was found that the STEAM approach requires a slight increase in the duration of the lesson or an increase in the number of independent work hours outside the lesson. However, the time spent is fully justified, since students understand the real economic and technical value of the topic they are studying (for example, alternating current circuits).

CONCLUSION

Research on the implementation of the STEAM approach in the process of teaching electrical engineering in higher education allowed us to draw the following conclusions:

1. The effectiveness of interdisciplinary integration: the STEAM approach raised electrical engineering from the level of a separate theoretical subject to the level of a complex engineering-innovative process. The integration of the components of Science, Technology, Engineering, Arts and Mathematics formed a holistic worldview in students towards science.
2. Growth of practical competencies: The results of the experiment showed that project-based education increased the practical skills of students by 24-30%

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compared to the traditional method. Students learned not only to calculate, but also to design, program and provide aesthetic design.

3. Creativity and innovation: The introduction of the "Arts" element into engineering disciplines activated the creative thinking of students. This will help future specialists develop into competitive specialists who can offer non-standard solutions.

4. Didactic transformation: It is advisable to reorganize electrical engineering laboratories in higher education institutions in the form of STEAM centers, introduce project assignments into curricula, and focus the assessment system on the final result (product).

In conclusion, the STEAM approach is not just a teaching methodology, but an effective didactic system for preparing learners for real-life and professional challenges in the age of high technology.

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