



“TEACHING METHODOLOGY OF THE ‘ELECTRODYNAMICS’ UNIT IN ACADEMIC LYCEUMS AND VOCATIONAL SCHOOLS”

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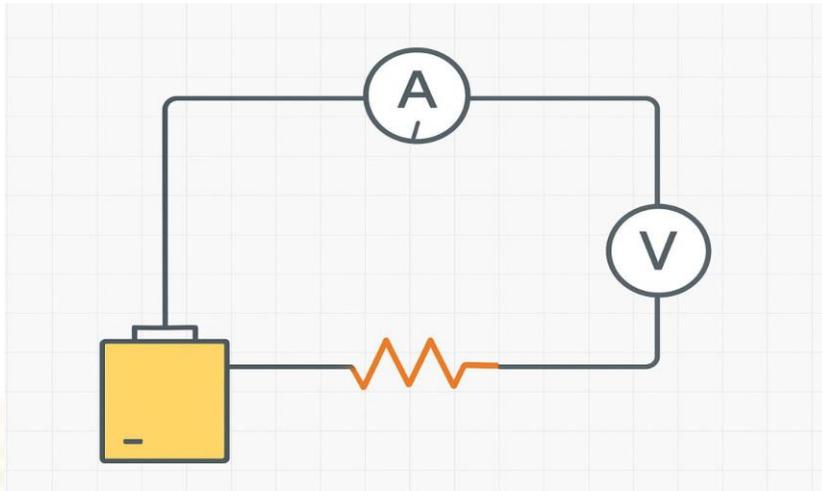
Abstract: *This article explores contemporary methodological approaches to teaching the “Electrodynamics” section in academic lyceums and vocational-technical schools.[1] It highlights the use of digital technologies, virtual laboratories, and interactive teaching methods. Through the integration of traditional instruction with modern technologies, the research aims to increase students’ interest in science, and to develop their independent thinking and practical skills. The article also discusses ways to organize hands-on activities, conduct experiments, assess students’ knowled.*

Keywords: *electrodynamics, modern educational technologies, interactive methods, virtual laboratory, STEAM approach, digital education.*

Introduction

Physics is one of the sciences that reveals the most fundamental laws of natural phenomena and connects them with real-life applications. Studying the properties of electrodynamics is one of the most important topics of this subject, as it explains to students the laws of electrostatics and electromagnetic wave theory. Today, the education system is rapidly digitalizing. In particular, the use of modern technologies in teaching natural sciences, including electrodynamics, enables learners to acquire knowledge not only theoretically but also in a practical, applied form. In academic lyceums and vocational-technical schools, lessons in this field play a significant role in shaping students’ professional orientations. Therefore, the use of interactive, problem-based, and innovative methods in teaching the “Electrodynamics” section is becoming increasingly necessary.[2] Within this topic,

I intend to illustrate the lesson “Measuring Electric Current Strength” through a virtual laboratory, and cultivate their ability to learn independently.



In our diagram, the “Measuring Electric Current Strength” laboratory is shown. The primary goal of conducting this laboratory exercise is, first of all, to clearly explain the concepts to students. Using a computer simulator, our main objective is to study the relationship between the current strength and the voltage in an electric circuit, and to verify Ohm’s law.

Electric current refers to the orderly movement of charged particles in one direction. The formula is

$$I = \frac{U}{R}$$

where:

I is the current strength,

U is the voltage,

R is the resistance.

As voltage increases, the current also increases in magnitude. This means that the currents coming into households through power lines also go up. If the voltage decreases, the current decreases as well. In our graph, if the relation between current strength I (on the vertical axis) and voltage U (on the horizontal axis) is a straight line, then Ohm’s law is correctly obeyed.

The simulator helps accurately model physical laws as in real experiments.

Main Part



1. The Importance of Modern Teaching Methods

In traditional lessons, the teacher often remains the primary source of knowledge, which can limit students' active participation and engagement. However, contemporary education emphasizes a “student-centered” principle, where learners are placed at the heart of the learning process. This shift necessitates the use of interactive methods — such as “Cluster,” “Insert,” “Debate,” “Role Play,” and “Pair Work” — to help students deeply understand electrodynamics topics.

Interactive teaching methods encourage students to engage cognitively, socially, and emotionally. According to pedagogical research, these approaches promote critical thinking, creativity, and collaboration.

For example, the “Cluster” method enables learners to organize ideas visually, making complex electrodynamics concepts more accessible and memorable. The “Debate” method helps students analyze and argue different theoretical perspectives, thereby reinforcing their conceptual understanding.

Furthermore, interactive methods support the development of transversal skills — such as communication, problem solving, and responsibility — which are essential in modern education.

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From a psychological perspective, the use of interactive and innovative approaches increases students' motivation, self-efficacy, and willingness to take intellectual risks.

In the context of physics (and specifically electrodynamics), such methods are particularly beneficial. Research has shown that “engaged pedagogy” — an interactive teaching model — significantly enhances students' understanding of physical principles, develops their critical-quantitative thinking, and improves retention of difficult concepts.

In summary, by integrating interactive, problem-based, and student-centered methods into electrodynamics lessons, educators can foster deeper conceptual



understanding, promote active learning, and cultivate essential 21st-century skills in their students. 2. Virtual Laboratories and Digital Technologies

In electrodynamics lessons, conducting experiments is not always easy due to limitations such as the availability of equipment, measurement instruments, and strict safety requirements. Therefore, virtual laboratories and simulation software (for example, PhET, Crocodile Physics, Tinkercad, Algodoo) offer significant opportunities.

In a virtual environment, students can:

safely test complex electric circuits;

visually explore the relationship between alternating voltage and current;

fully observe the propagation of electromagnetic waves through 3D animations.

This method not only makes the lesson more engaging, but also helps develop students' practical and engineering thinking.

The PhET Interactive Simulations project, for example, provides an intuitive, game-like environment where students can explore circuits, fields, and waves, making abstract phenomena more concrete.[4]

Algodoo, on the other hand, is a 2D physics sandbox which allows users to create and manipulate objects with physical properties (e.g., charge, mass, forces), giving students hands-on experience in a safe, virtual setting.

Crocodile Physics is another tool used in virtual lab instruction; it enables the simulation of a wide variety of physical processes, including those that might be difficult or unsafe to recreate in a school lab.

Overall, integrating these digital technologies into electrodynamics teaching supports deeper conceptual understanding, enhances student engagement, and builds confidence in experimenting.

3. STEAM and Project-Based Teaching

In modern education, the STEAM (Science, Technology, Engineering, Art, Mathematics) approach empowers students to apply their knowledge to real-world



problems through project-based learning.[3] For example, under a project titled “Electric Energy Saving”, students might: calculate the efficiency of an electric circuit; identify the causes of energy losses; design and build a model (scale) of an energy-saving system.

Such project-based teaching nurtures creative thinking, independent decision-making, and an engineering mindset in students. Research has shown that project-based learning within a STEAM framework significantly improves students’ learning outcomes in science, particularly promoting problem-solving and critical thinking skills.

4. Example in Electrodynamics: Electromagnetic Induction Project

For instance, when teaching the topic “Electromagnetic Induction”, students can be divided into small groups and tasked with designing their own experimental project. They would plan and conduct observations (virtually or physically), collect data, and then draw conclusions based on their results. This not only strengthens their scientific reasoning but also enhances collaborative skills and ownership of their learning.[5]

Through such a STEAM-inspired project, learners engage actively, apply theoretical principles, and develop both technical and soft competencies — all of which align with the goals of modern, student-centered education. During the lesson, the effectiveness of teaching can increase significantly by using multimedia tools and animations, interactive tests, 3D models, and virtual teachers powered by artificial intelligence. AI-based learning platforms (for example, ChatGPT, Khanmigo, LearnAI) can greatly assist students in independent review and in understanding complex concepts.

Multimedia tools (animations, 3D models etc.) help visualize abstract electrodynamics phenomena, making them more accessible to learners.

Interactive tests enable immediate feedback, reinforcing students’ conceptual understanding.



AI tutors can provide personalized explanations, answer students' questions, guide them through difficult topics, and adapt to individual learning paces. This kind of adaptive, AI-enabled learning supports a student-centered approach.

In particular, platforms like Khanmigo (developed by Khan Academy) are being used in educational contexts to offer tailored, on-demand support. For example, AI-driven systems can analyze a student's knowledge level and create or adjust learning paths accordingly.

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Research into multimodal large-language models (MLLMs) shows that they can process not only text but also images and other modalities, providing richer, more interactive science learning environments.

Moreover, recent studies demonstrate the use of generative AI for simulation-based physics experiments: students prompt, refine, and validate AI-constructed simulations of physical phenomena, which enhances both their conceptual understanding and modeling skills.

Thus, integrating multimedia and AI into teaching electrodynamics not only makes lessons more engaging and individualized, but also helps develop students' higher-order thinking and modeling competencies.

Conclusion

In academic lyceums and vocational-technical schools, incorporating modern pedagogical technologies, virtual laboratories, interactive methods, and artificial intelligence in teaching the Electrodynamics section broadens students' scientific worldview, deepens the connection between science and practical professions, and cultivates skills in independent inquiry and innovative thinking.

A methodological approach harmonized with modern technologies — combining AI, multimedia, and interactive pedagogy — is fundamentally important for training competitive, thoughtful, and practically active specialists in the future.



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