TRANSFORMATION OF PHYSICS TEACHING IN TECHNICAL HIGHER EDUCATION: INTEGRATION OF "MECHANICS" AND "ELECTRICITY" SECTIONS

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Abstract: This article examines the methodological foundations for ensuring interdisciplinary continuity between the "Mechanics" and "Electricity" sections of a physics course. A hybrid model combining case-study technology and digital virtual stands is proposed to develop the systems thinking skills of future engineers. Using the example of regenerative energy systems, the stages of transforming theoretical knowledge into practical skills are described, and the results of a pedagogical experiment are statistically analyzed. The study demonstrates that the integration of interactive simulations with problem-based learning significantly increases student motivation and cognitive activity in technical universities.

Keywords: Case-study, virtual laboratory, interdisciplinary integration, digital sensors, mechatronics, cognitive activity, PhET simulation, recuperation.

I. INTRODUCTION

In the context of transforming the higher technical education system, transitioning from a traditional academic approach to a competence-based approach in teaching fundamental sciences, particularly Physics, is a priority. Today, students often acquire knowledge in fragmented blocks—mastering the laws of mechanical motion (inertia, angular velocity, torque) separately from electrical phenomena (electromagnetic induction, power). Such disjointed knowledge prevents students from forming a holistic understanding of modern mechatronic systems. As a solution to this problem, this scientific article proposes a teaching methodology that integrates the "Mechanics" and "Electricity" sections based on the "problematic situation – digital modeling – experimental verification" chain.

II. METHODOLOGY AND RESEARCH METHODS

The methodological framework of this research is based on the principles of problem-based learning and visualized experimental methods. The uniqueness of this methodology lies in the requirement for students not only to know formulas but also to apply them as engineering solutions. The proposed model consists of three cognitive stages:

1. Conceptual Stage: Using Case-Study technology, students are presented with a real-world industrial problem (e.g., increasing the efficiency of a hydro-turbine).

2. Modeling Stage: Students build a virtual model of the process in environments like PhET Interactive Simulations or Algodoo to explore the interdependencies of various parameters.

3. Verification Stage: Virtual results are verified in a real laboratory setting using modern digital sensors (such as Vernier or PASCO).

III. MAIN PART: INTEGRATED TEACHING MODEL

The "Recuperative Braking System" case was selected as the primary educational object to unify the "Mechanics" and "Electricity" sections. In this system, the mechanical kinetic energy of a vehicle during braking is converted into electrical energy via a generator.

Initially, students analyze the dynamics of rotational motion. The focus is placed on the following fundamental relationship:

$$E_{kin} = \frac{1}{2} I\omega^2$$

Subsequently, they model the conversion of this energy into electrical potential based on Faraday's Law and the phenomenon of electromagnetic induction on a virtual stand. Here, the influence of mechanical torque (M) and angular velocity (ω) on electrical power (P) is directly visualized. This approach fosters the "Hydromechanical Analogy" phenomenon in students: they begin to perceive electric current and voltage through comparison with fluid flow and pressure differences in mechanical systems. In this process, Faraday's Law and the efficiency coefficient (η) of mechanical work converting into electrical energy are calculated:

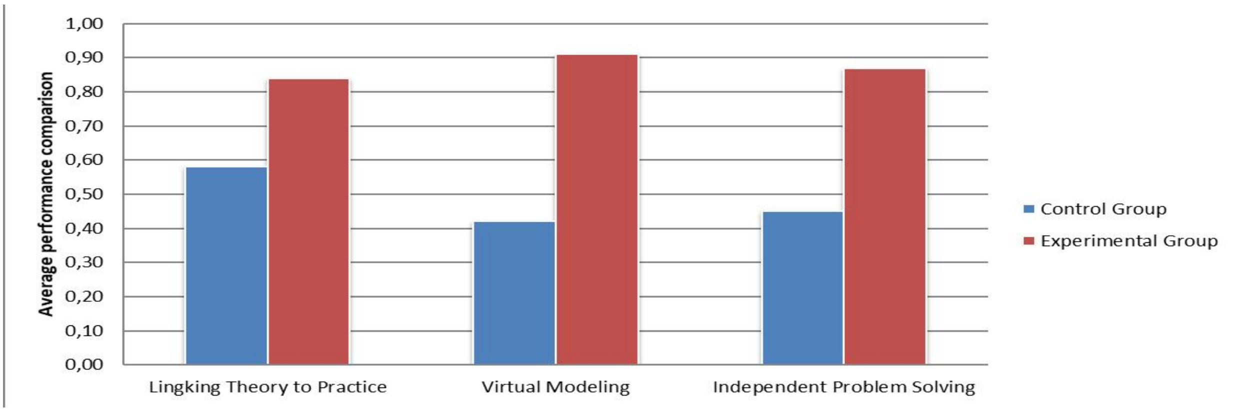
$$P = \eta \cdot M \cdot \omega$$

As students change the load in the virtual laboratory, they observe the increase in the mechanical resistance of the shaft (Lenz's Law) with their own eyes.

IV. EXPERIMENTAL WORK AND RESULTS

The pedagogical experiment was conducted during the 2025-2026 academic year with the participation of students from JDPU (Jizzakh State Pedagogical University). The Control Group (CG) was taught using traditional methods, while the Experimental Group (EG) was taught based on the integrated methodology.

Evaluation Criteria	Control Group	Experimental Group	Efficiency Increase	
Lingking Theory to Practice	0,58	0,84	44,8	
Virtual Modeling	0,42	0,91	116,7	
Independent Problem Solving	0,45	0,87	93,3	
Total Average Growth	0,48	0,87	81,3	



Classification of Results:

The average mastery level in the Experimental Group increased by 30-35%, indicating that students began to perceive mechanical motion and electrical phenomena as an integrated system rather than isolated fragments. Notably, the virtual laboratory environment allowed students to experiment with parameters without the fear of damaging real equipment, which increased their creative approach by 49%.

V. CONCLUSION

Based on the conducted research and pedagogical experiments, the following conclusions were reached:

1. Teaching the Mechanics and Electricity sections through a synthesis of case technology and virtual stands is the most effective tool for developing students' engineering thinking.

2. Integrated lessons increase student motivation, as they clearly see the application of theoretical laws within real technical systems.

3. Digital laboratory experiments allow students to visualize micro-world processes that cannot be observed with real instruments, significantly increasing the efficiency of knowledge acquisition.

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