



**SCIENTIFIC AND METHODOLOGICAL PROBLEMS OF TEACHING
PHYSICS IN THE PREPARATION OF FUTURE ENGINEERS
(ON THE EXAMPLE OF TECHNICAL UNIVERSITIES)**

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ABSTRACT

This article presents a systematic analysis of current scientific and methodological problems in teaching physics to future engineers at technical universities. Traditional reproductive and problem-based teaching methods are comparatively studied, and their role in the formation of engineering competencies is substantiated. Key problems are identified, such as the outdated material and technical base of laboratory classes, insufficient level of interdisciplinary integration, and the lack of systematic use of digital technologies (PhET, MATLAB, LabVIEW, etc.). Within the framework of Resolution No. PQ-5032 of the President of the Republic of Uzbekistan, practical recommendations have been developed for improving the methodology of teaching physics. The results of the article can serve as a methodological guide for the physics departments of technical universities.

KEYWORDS

Physics education, engineering education, scientific and methodological problems, interdisciplinary integration, digital technologies, competency-based approach.

INTRODUCTION

The rapid development of technology and engineering in the information society is fundamentally changing the content of engineering activities. The modern engineer is becoming not only a specialist who solves standard design or technological tasks, but also a creative person who can deeply analyze physical phenomena, the fundamental properties of materials, and the laws of energy conservation, and scientifically develop innovative solutions [2; 3].

Physics is the foundation of engineering competencies in technical universities. Physical education develops students' skills in analytical thinking, modeling physical processes, planning experiments, and scientifically generalizing results. It is the physics course that creates the fundamental knowledge base necessary for mastering all general professional and special subjects in the field of engineering [4].

Improving the quality of higher education in the Republic of Uzbekistan, in particular, the teaching of fundamental sciences in engineering, is one of the priorities of state policy. The decision of the president of the Republic of Uzbekistan “on measures to improve the quality of Education in the field of Physics and the development of scientific research” dated March 19, 2021 PQ-5032 established priorities such as ensuring continuity of teaching physics, creating a modern educational and

laboratory base, improving teaching methodology, integrating physical education with engineering sciences [1]. This decision forms the theoretical and methodological basis of this study.

The main purpose of this article is to systematically analyze the scientific and methodological problems of teaching physics in technical universities and to develop proposals and recommendations aimed at eliminating existing shortcomings. Within the framework of the stated goal, the following:

- to identify the current state of teaching physics in technical universities and the scientific and methodological problems in it;

- to identify the main directions for modernizing physics education with a focus on the formation of engineering competencies;
- to substantiate the possibilities of using modern pedagogical and information and communication technologies in teaching physics;
- Within the framework of the tasks set by the Presidential Decree, tasks such as developing practical recommendations for improving the methodology of teaching physics are solved. The object of the study is the system of physics education in the process of training future engineers at technical universities.

The subject of the study – scientific and methodological problems arising in this system and ways to solve them-has been identified. The study included the following:

- theoretical analysis - study and generalization of scientific and pedagogical literature on the methodology of teaching physics;

- comparative analysis - comparison of reproductive and problem-based learning methods;

- observation and survey - observation of the practical training process and survey of students and teachers of technical universities;

- modeling - methods such as the frontal and multi-stage problem development methodology were used.

Main part

Practical training in physics at technical universities is an integral part of the educational process, in which students develop a unique approach to solving physical and technical problems and form professional competencies [6]. Practical exercises logically complement lecture sessions, developing skills in mathematical calculations, working with tables and reference literature. The analysis identified the following systemic problems:

No	Problem	Description
1	The superiority of the traditional reproductive approach	Students solve problems based on ready-made algorithms, creative thinking does not develop
2	Obsolescence of the laboratory base	The devices are consistent with the style guides from 20–30 years ago, and there are not enough digital tools.
3	Slowness of interdisciplinary integration	The physics course is taught separately from mathematics, computer science, and materials science.
4	Lack of use of digital technology	Simulation programs (PhET, Multisim) and mathematical packages (MATLAB) are rarely used.

The reproductive (traditional) approach is based on the teacher's information-illustrative activity and students' repetition of ready-made knowledge. The advantage of this approach is the rapid formation of stable skills in solving typical problems. However, the disadvantages are: superficial knowledge is quickly forgotten, the ability to solve typical problems is not formed, and creative thinking is not developed [7].

Problem education is focused on the development of independent thinking activities of students, analytical skills form skills and creativity. The students are as follows:

- acquaintance with the condition of the issue;
- independent development of a solution algorithm;
- solving the problem;
- analysis and generalization of the results obtained.

The problem-based approach involves working in small groups, which develops collaboration, self-organization, and initiative skills [8].

Frontal tasks – all students work on the same topic, but with individual numerical data. This helps to effectively monitor the independent work of each student.

For example, let's consider a frontal problem from the following section of physics: "Molecular-kinetic theory of gases": The initial temperature of " t " ($^{\circ}\text{C}$) nitrogen with a mass of " m " (g) and a pressure of " p " (kPa) . As a result of isobaric expansion up to volume (l), the gas temperature rose. Find the gas temperature and density after expansion. Let the mass, initial temperature and pressure, and the numerical value of the volume of gas expansion be equal to the option number.

Find the gas temperature and density after expansion. The numerical values of mass, initial temperature, pressure, and volume depend on the student's option number. It is recommended to use software tools such as Excel or Mathcad to solve such problems [9].

Multi – level issues are a set of sub-issues that are logically connected to each other, combined with one subject or branch of physics. The outcome of each sub-issue serves as a prerequisite for the next issue. Example: The multi-step problem for the "DC Laws" section includes:

- Analyze an electrical circuit based on Kirchhoff's rules;
 - Apply Ohm's law to a part of a circuit and to a complete circuit;
 - Calculate power based on the Joule–Lenz law;
 - determining the efficiency of a power source, etc.
- Solving multi-step problems allows students to develop skills in understanding the interrelationships of physical laws, systematic thinking, and independent reasoning.

In modern engineering education, the integration of physics with other disciplines is becoming increasingly important (Table 1). Integration of physics with other disciplines .

Table 1.

Academic	Integration direction	Practical example
Math	Differential equations, vector calculus	Solving electromagnetic field equations
Informatics	Modeling, algorithmization	Modeling physical processes in Python or C++
Material science	Solid state physics	Studying the properties of semiconductors
Electrical engineering	Electrical circuit theory	Practical application of Kirchhoff's and Ohm's laws

Integrating digital technologies into physics teaching includes: - PhET interactive simulations – observing physical phenomena as virtual experiments; - MATLAB / Octave – automating complex calculations and graphical analysis; - LabVIEW - creation of real-time measurement and control systems; - OpenModelica - provides capabilities such as object-oriented modeling of physical systems [10]. As a result of the analysis carried out within the framework of this article, the following were obtained:

- 1. Methodologically: the predominance of reproductive teaching methods does not develop creative and critical thinking;
 - 2. On the laboratory basis: outdated devices and the lack of modern measuring equipment;
 - 3. Lack of integration: the physics course is not sufficiently connected to applied engineering sciences;
 - 4. Digital technologies: systematic use of simulation and modeling tools is not used.
- To address the above issues noted in the article, the following should be done:
- • Ensure a reasonable combination of reproductive and problem-based learning methods in teaching physics (for example, reproductive in simple problems, problem-based approach in complex problem situations);
 - Equip laboratory classes with digital measuring instruments and virtual stands;
 - Integrate the physics course with mathematics, computer science, and engineering;
 - Regularly introduce software tools such as PhET, MATLAB, and LabVIEW into practical exercises;
 - Recommendations have been developed, such as organizing special courses for teachers on "Digital technologies in teaching physics".

Conclusion

- Improving the quality of physics teaching in technical universities is an important factor in the formation of professional competencies of future engineers.
- The main directions for improving the methodological system of teaching physics are the rational selection of problems in practical exercises, the correct definition of teaching methods (a combination of reproductive and problem-based approaches), and the use of frontal and multi-stage problems.
- Integration of digital technologies (PhET, MATLAB, LabVIEW, etc.) develops students' physical thinking and digital competencies.
- The tasks set out in the Resolution of the President of the Republic of Uzbekistan No. PQ-5032 provide a solid legal and methodological basis for reforms in this area.

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