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METHODOLOGY FOR TEACHING PHYSICS THROUGH INTEGRATION WITH MILITARY-TECHNICAL TRAINING

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Abstract

This article analyzes the theoretical and practical foundations of teaching physics based on integration with the discipline of military-technical training. The study also highlights the didactic potential of integrated educational technologies, the methodology of organizing training sessions, and their significance in developing the cognitive abilities of students (cadets). The research results demonstrate that integrating physics with military-technical disciplines contributes to the development of cadets' practical thinking, the formation of their professional competencies, and enhances their interest in military-technical training.

Keywords: integrated education, physics, military-technical training, teaching methodology, technical thinking, practical training, interdisciplinary logical correlation.

Introduction

In modern education, interdisciplinary integration plays a vital role in developing scientific-technical thinking, systematic reasoning, practical preparedness, and professional competencies among cadets. The science of physics, with its universal laws, forms the scientific foundation for teaching military-technical training subjects. Therefore, teaching physics in an integrated manner with military-technical disciplines develops not only cadets' theoretical knowledge but also their ability to apply it in real military service conditions. In Uzbekistan, modernization of military education, fostering patriotism among youth, and developing military-technical thinking have become matters of state policy. This has led to recognition of the need to integrate military education with natural sciences [1]. The above considerations confirm that organizing physics lessons through integration with military-technical training represents one of the modern pedagogical approaches.

Literature Review

The idea of integrated education was first proposed by J. Dewey and J. Bruner, who argued that knowledge is better mastered when subjects are interrelated within the learning process [2]. The Russian scholar A. M. Matveev [3] revealed the methodological aspects of integration in his studies, emphasizing that interdisciplinary connections ensure the comprehensive development of students' thinking. Uzbek pedagogical scientists such as A. G'ulomov, M. Tursunov, and

Sh. Kholmurodov [4], [5] have also highlighted the innovative significance of integrative learning. Their studies show that linking physics with military-technical disciplines not only strengthens theoretical understanding but also fosters the development of professional competencies among cadets. In addition, numerous pedagogical studies confirm that integrative, interactive, and competence-based approaches in education are highly effective in promoting the comprehensive development of learners. Integration of natural sciences (particularly physics) with practical, technical, and military-training directions helps students acquire practical competencies [6]. The analysis of historical sources shows that the evolution of educational processes has progressed from individual instruction toward integrated, complex, and competency-oriented approaches. Integrated lessons—especially those combining physics and military-technical training—develop interdisciplinary thinking, reinforce the connection between theory and practice, and fully align with modern educational requirements.

Research Methodology

The methodological basis of this research relies on modern pedagogical technologies, the theory of integrative education, and the concept of interdisciplinary approaches. The main objective of the study is to determine the effectiveness of teaching physics through integration with military-technical training disciplines and to develop cadets' professional skills by linking military-technical knowledge with physical processes in a logical manner. At the theoretical stage of the study, advanced foreign and domestic research on integrative education, interdisciplinary relations, military-pedagogical approaches, and technical directions was analyzed. Pedagogical and methodological literature, curricula, regulatory documents, and conceptual papers related to the military education system of the Armed Forces of the Republic of Uzbekistan were examined. Based on this analysis, scientific and theoretical foundations for organizing integrated lessons were developed. Using the pedagogical observation method, the study explored the dynamics of the learning process in real classroom conditions—specifically, cadets' activity levels, learning performance, and interest indicators.

Cadets' Average Learning Performance

Table 1

Group	Average points	Comment
Control group	7.8	Traditional teaching method
Experimental group	9.0	Based on an integrated approach

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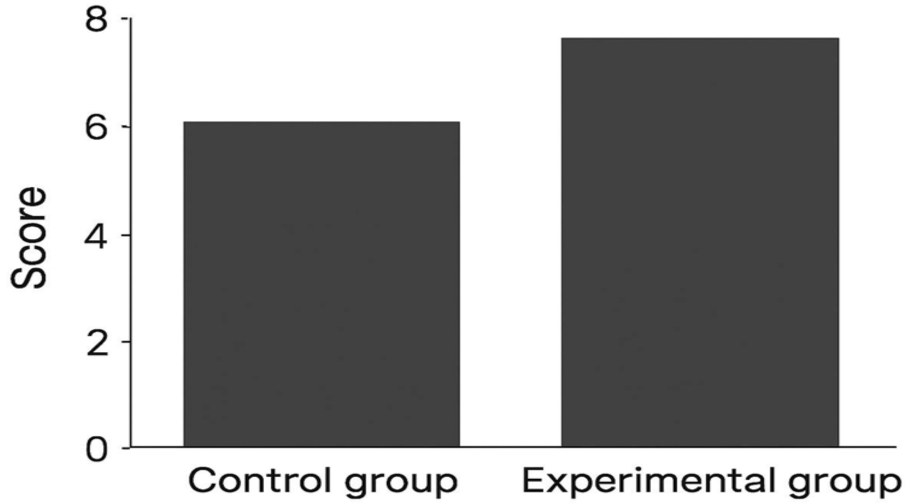

Figure 1. Analysis of Experimental and Control Group Results

Observations were conducted at the Military Training Center of the National University of Uzbekistan during the 2023–2024 academic year. The findings identified both the strengths and weaknesses of the integrative education process and provided practical data necessary for the experimental phase. The experimental test served as the core stage of the study, involving a total of 44 cadets divided into two groups — an experimental group and a control group. Lessons in the experimental group were conducted using an integrated approach that combined physics with military-technical training subjects, while the control group followed traditional teaching methods. To measure changes in cadets' knowledge, skills, and competencies, the research employed specially designed diagnostic tests, surveys, and practical assignments. The data obtained were statistically analyzed, verified for reliability, and compared using tables and diagrams. The results showed that the average academic performance of cadets in the experimental group was 1.2 points higher than in the control group. During the modeling process, the interrelation between physical phenomena and military technologies was visualized through computer graphics and schematic diagrams. For example, the physical foundations of electrical systems and automation components of combat equipment were modeled and integrated into lessons. This approach enhanced cadets' analytical and creative thinking by linking physical concepts with real military-technical processes. The combined use of these methods confirmed the scientific validity, practical applicability, and effectiveness of the integrated learning model. Furthermore, it contributed to establishing strong logical and functional connections between physics and military-technical training subjects in the educational process.

Analysis and Results

The term integrative approach refers to the combination of content and methods from different disciplines to form a holistic modern worldview in students or cadets. Teaching physics through integration with military-technical training expands opportunities to apply theoretical

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knowledge to real military service activities. In this process, the laws of physics are connected to the principles of operation of military equipment and weapons. The main goal of integration is to enable effective use and correct operation of military equipment and weapons by combining the necessary physical knowledge with practical skills. Lessons organized on the basis of an integrative approach serve to develop in cadets the ability to apply physical knowledge in real situations, to understand the structure of the material parts of military equipment, to comprehend the physical processes occurring during the operation of aggregates and mechanisms, to make quick decisions in complex conditions, and to think independently. This, in turn, increases the professional competence of future officers. Experience in organizing integrated lessons shows that studying theoretical laws of physics through examples from military technology makes the lessons more interesting, meaningful, and practically valuable for cadets.

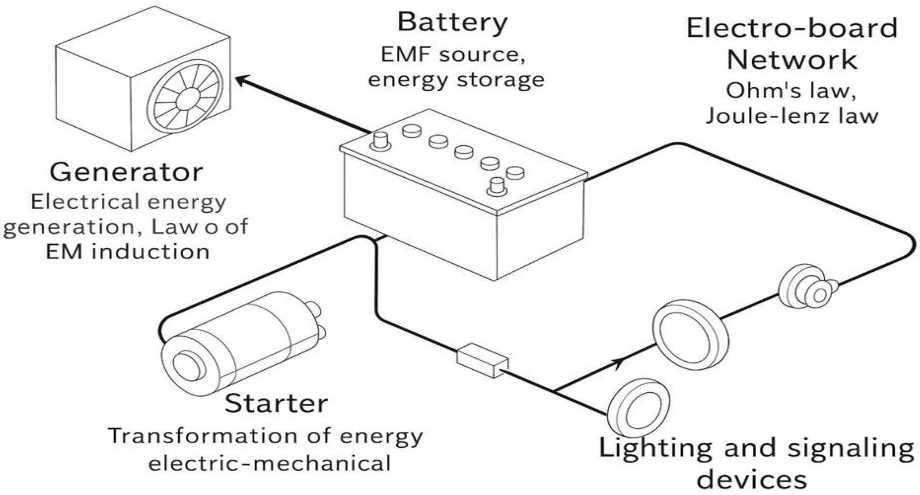

Figure 2. The Interrelation Between Physics and Military-Technical Training Disciplines.

The primary tasks of this research included explaining physical laws through examples of technical equipment, developing technical thinking, increasing the efficiency and quality of using combat equipment, ensuring a close link between theory and practice (see Figure 2). When studying the electrical special devices and automation elements of combat vehicles in military-technical training, the following examples can be given with the aim of integrating this subject with physics. For example, the electromotive force (EMF) is a physical quantity that expresses the action of external (potential) forces in energy sources of direct or alternating current. In order for an electric current to flow through a conductor, an electric field must be created and maintained in it. To achieve this, the potential difference between the ends of the conductor is continuously restored by means of a current source. This means that the positive charges flowing in the direction of the current must be continuously carried away from the conductor’s low-potential end and brought to its high-potential end. As a result, a closed movement of charges occurs.

In this case, internal electrostatic (internal) forces alone are not sufficient, since the work they perform in moving charges around a closed path equals zero. The work done by external forces in moving a unit positive charge around the closed circuit is called the electromotive force

(EMF) of the current source. Therefore, the EMF is the energy introduced into the circuit under the influence of external forces and is measured in volts. Galvanic cells, accumulators, direct current generators, semiconductor thermoelements, photoelements, and others can serve as sources of EMF.

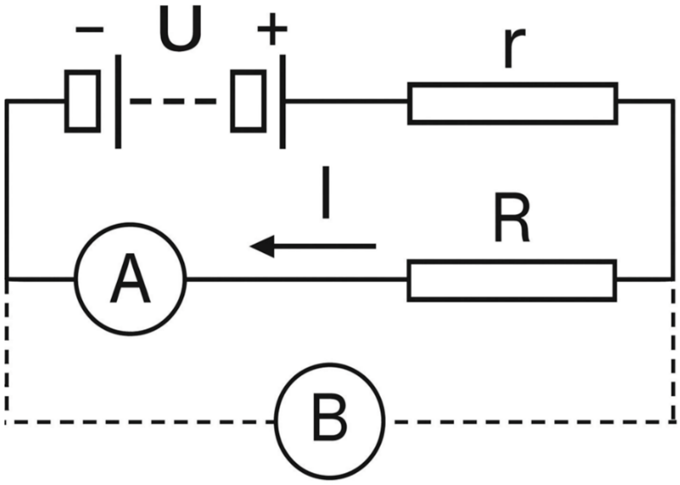

Figure 3. A diagram representing the three components of Ohm's Law.

The value of the current I in the circuit is directly proportional to the EMF ε of the source and inversely proportional to the sum of the internal and external resistances R + r.

$$X = \frac{a}{b + l} \qquad (1) \qquad\qquad I = \frac{\varepsilon}{R + r} \qquad (2)$$

Ohm's Law is an experimentally established physical law that determines the relationship between the electromotive force (EMF) or voltage of a source, the current strength, and the resistance of the conductor. In its original form, this law was expressed by its author as follows (1), where X represents the galvanometer readings — that is, in modern terms, the current I; a represents a quantity characterizing the properties of the voltage source, which is constant within wide limits and independent of the amount of current — in modern terminology, this is the "electromotive force (EMF)" ε; l represents the length of the connecting wires — corresponding, in modern understanding, to the "external resistance R"; and b represents a parameter characterizing the entire device, which in modern terms corresponds to the "internal resistance r" of the power source. Thus, in modern notation and according to the author's proposed expression, "Ohm's Law (1)" can be written as follows, where ε is the EMF of the source, I is the current in the circuit, R is the resistance of all external elements of the circuit, and r is the internal resistance of the voltage source. From Ohm's Law for the complete circuit, the following conclusions can be drawn: If $r \ll R$, then the current strength in the circuit is inversely proportional to its resistance. In this case, the source is sometimes called a "voltage source." If $r \gg R$, the current strength does not depend on the properties of the external circuit (on the value of the load). In this case, the source is called a "current source." Often, the following expression is also referred to as Ohm's Law: U = IR, (3) where U is the voltage or voltage drop (that is, the potential difference between the ends of the conductor). Thus, according to formulas (2) and (3), when a current flows through a closed circuit, the electromotive force is equal to:

ε = I r + I R = U(r) + U(R), (4). That is, the sum of the voltage drops across the internal resistance of the power source and the external circuit is equal to the EMF of the source. The last term in this equation is referred to by specialists as the "voltage at the terminals," since it is this quantity that is measured by a voltmeter connected between the beginning and end of the closed circuit attached to the source. In this case, it is always less than the EMF. Formula (3) can also be written in another form, namely: I = U / R, (5) and in this case the following definition applies: "The current strength in a section of a circuit is directly proportional to the voltage and inversely proportional to the electrical resistance of that section." Expression (5) can also be written as: I = U G, (6), where G is the proportionality coefficient, called conductance or electrical conductivity. Previously, the unit of conductance was the "reciprocal ohm (Mho)," but in the International System of Units (SI), the unit of conductance is the siemens (Russian designation "Sm," international "S"), which is equal to one reciprocal ohm. As a result of conducting lessons based on integration with military-technical training, there was a noticeable increase in the depth of knowledge assimilation, motivation, development of practical thinking, and the ability to work in teams. At present, the concept of pedagogical technology occupies a firm place in the educational process and is regarded as an integral part of modern pedagogical practice. Pedagogical technology is the combination of theoretical achievements of pedagogy and practical experience, serving to organize the learning process effectively, improve the quality of teaching, and develop independent thinking skills in learners. One of the most effective forms in this direction is the integrated lesson. Integrated lessons ensure the interrelation between several subjects, help learners perceive the surrounding world as a whole, understand cause-and-effect relationships between different sciences, and connect theoretical knowledge with practice [7]. Teaching physics through integration with military-technical training directs cadets toward technical thinking, analytical reasoning, and the ability to find creative solutions in complex conditions, since most military-technical processes are based on physical laws such as mechanics, energy balance, motion and force, optics, and electromagnetism. Therefore, the integration of these subjects develops practical competencies in cadets. In the integrated learning process, binary lessons are of particular importance. A binary lesson is a session jointly conducted by two teachers of different subjects, during which students (cadets) analyze one topic from the perspectives of both disciplines. In such lessons, the student (cadet) becomes not only a recipient of knowledge but also an active participant, analyst, and creator. This, in turn, develops meta-disciplinary competencies — that is, universal skills such as applying knowledge in real life, communication, independent decision-making, creativity, and critical thinking [9]. Analyses have shown that teaching physics through integrated lessons with military-technical training results in the following:

- students' (cadets') ability to apply theoretical knowledge in practice increases;
- the level of creative and analytical thinking improves;
- a coherent system of interdisciplinary knowledge is formed;
- professional motivation and a sense of responsibility among cadets strengthen;
- new forms of cooperation between teachers and students emerge.

In addition, such lessons help prepare students for research activities, defending their ideas, and analyzing results. Pedagogical technologies used in integrated education — such as projectbased learning, problem-based instruction, and interactive methods — ensure active participation of cadets in the learning process [10]. Based on observations and experimental studies, it was determined that integrated lessons lead to an increase in students' knowledge quality by 15–20%, and their ability for independent and analytical thinking by 25–30%, confirming the effectiveness of integrating physics with military-technical training. Thus, teaching physics on the basis of integrated lessons with military-technical training:

- connects the content of education with real life;
- develops universal (meta-disciplinary) competencies;
- directs students toward creative activity;
- fully meets the requirements of modern educational standards.

Conclusion/Recommendations

According to the results of the research, teaching the subject of physics based on integration with the subjects of military-technical training significantly increases the effectiveness of the educational process. Such an approach develops scientific-technical thinking and practical skills in students, forms military-professional competencies, enables the systematization of interdisciplinary knowledge, and strengthens cadets' interest in the military field and technical sciences.

Recommendations

1. To develop methodological manuals for physics teachers that are related to the subjects of military-technical training.
2. To establish integrative laboratories in military education departments.
3. To train teachers in the methodology of interdisciplinary integration within professional development courses.
4. To include new laboratory works based on military-technical examples in the curricula.
5. To organize practical competitions among cadets on the topic: "Prospects for the Application of Achievements in Physics to the Military-Technical Field."

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