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DEVELOPING STUDENTS' INTELLECTUAL THINKING IN PHYSICS LESSONS THROUGH SOLVING QUALITATIVE PROBLEMS

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Abstract

The article examines the role of qualitative problems in developing students' intellectual thinking during physics lessons. It is shown that the use of such problems contributes to the formation of logical thinking, the ability to analyze physical phenomena, and the identification of cause-and-effect relationships. The possibilities of qualitative problems in enhancing students' cognitive activity and interest in learning physics are discussed. Their importance for developing learners' independence and research skills is substantiated. It is concluded that the systematic use of qualitative problems is essential for improving the effectiveness of physics education.

Keywords: Qualitative problems, physics, intellectual thinking, logical thinking, cognitive activity, research activity, physics education, school students, physics teaching.

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РАЗВИТИЕ ИНТЕЛЛЕКТУАЛЬНОГО МЫШЛЕНИЯ УЧАЩИХСЯ НА УРОКАХ ФИЗИКИ ПОСРЕДСТВОМ РЕШЕНИЯ КАЧЕСТВЕННЫХ ЗАДАЧ

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Аннотация

В статье рассматривается роль качественных задач в развитии интеллектуального мышления учащихся на уроках физики. Показано, что их использование способствует формированию логического мышления, умения анализировать физические явления и устанавливать причинно-следственные связи. Рассматриваются возможности качественных задач в повышении познавательной активности и интереса школьников к изучению физики. Обосновывается их значение для развития самостоятельности и исследовательских навыков обучающихся. Сделан вывод о необходимости систематического применения качественных задач в процессе обучения физике.

Ключевые слова: качественные задачи, физика, интеллектуальное мышление, логическое мышление, познавательная активность, исследовательская деятельность, физическое образование, школьники, обучение физике.

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Introduction

In the current landscape of educational development, pedagogical science faces significant tasks aimed at improving the quality of instruction in natural science disciplines. Fostering a sustained interest in physics among schoolchildren—and ensuring they grasp the practical significance and universal nature of physical laws—has become particularly relevant. Equally important is the creation of an educational environment that unlocks each student's intellectual potential and cultivates their cognitive engagement, research skills, and capacity for independent logical reasoning. Addressing these objectives entails not only mastering the curriculum but also developing the key competencies essential for success in both academic pursuits and future professional endeavors.

The effectiveness of achieving these goals depends largely on the physics teacher's professional competence. This competence encompasses a combination of pedagogical, organizational-technological, and personal qualities that ensure the successful implementation of the educational process. It is the teacher's level of professional training, methodological expertise, and ability to employ modern educational technologies that create the conditions for effective student learning and development [5].

Physics teachers employ a wide array of instructional methods, techniques, and technologies. A judicious blend of traditional and innovative approaches to organizing both classroom and extracurricular activities is of particular importance. Such an approach makes it possible to accommodate individual student needs, foster cognitive interest, and enhance the effectiveness of learning the material.

Years of pedagogical experience demonstrate that developing students' logical thinking remains one of the most critical challenges in school-level physics education. A promising strategy for addressing this issue is the systematic use of qualitative problems within the instructional process. Working with such problems helps students develop skills in analyzing physical phenomena,

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establishing cause-and-effect relationships, and honing their ability to reason, compare, generalize, and draw well-founded conclusions [7].

The study of physics should not be limited to the rote memorization of formulas and algorithms for solving quantitative problems. The primary goal of physics education is to shape a scientific worldview, develop intellectual abilities, and foster an understanding of the principles governing the world around us. In this context, qualitative problems serve as a vital didactic tool that facilitates the meaningful assimilation of physics knowledge and the development of students' thinking skills.

A qualitative physics problem is defined as one that focuses on the qualitative aspects of a physical phenomenon and is solved through logical reasoning based on physical laws—or by creating a diagram or conducting an experiment—without the use of mathematical calculations [2].

A distinction should be made between a qualitative problem and a question designed merely to test rote knowledge (examples of qualitative problems include: Why is it recommended to wind a mechanical watch in the morning rather than in the evening? Why cannot a bird that has fallen into a well get out? Why does a small piece of metal sink in water, whereas a massive metal ship does not?). A qualitative problem poses a question for which the answer is not explicitly provided in the textbook (for example: if a moving car brakes sharply, its front end dips; why?). The student must formulate an answer by synthesizing the given conditions of the problem with their existing knowledge of physics.

Solving qualitative problems facilitates the implementation of the didactic principle of the unity of theory and practice in physics instruction. In particular, the use of experimental problems develops students' skills in handling physical instruments, mock-ups, setups, and models. Qualitative problems with industrial or technical content familiarize students with technology, broaden their horizons, and serve as a means of preparing them for practical work. Thus, solving qualitative physics problems is a key method in polytechnic education.

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The use of qualitative problems fosters a deeper understanding of physical theories and the formation of accurate physical concepts, thereby preventing rote, superficial learning. Solving qualitative problems necessitates the analysis and synthesis of phenomena—that is, logical thinking—and accustoms students to precise, concise, and linguistically and technically correct speech [3].

The process of solving qualitative problems fosters observational skills and the ability to distinguish physical phenomena in nature, everyday life, and technology, rather than solely within the physics classroom. It develops students' ingenuity, quick-wittedness, initiative, and creative imagination.

To solve a qualitative problem, a student must be able to think like a physicist: understanding and articulating the nature of the states of bodies and the processes occurring within them, uncovering the interrelationships between phenomena (cause-and-effect dependencies), and predicting the course of a phenomenon based on the laws of physics. Thus, solving qualitative problems enables the teacher to assess the depth of a student's theoretical knowledge and their understanding of the material being studied.

The methodological value of qualitative problems is particularly evident when studying sections of the physics curriculum that do not involve formulas and where phenomena are examined solely from a qualitative perspective (for example, the law of inertia or electromagnetism).

Qualitative problems play a significant role in extracurricular activities, such as physics clubs, "recreational physics" evenings, school, regional, and national Olympiads, as well as competitions and matches involving KVN teams and other groups.

Psychology highlights a specific characteristic of middle-school-aged children: concrete-imagistic thinking. Concepts based on concrete objects and tangible visual aids are more accessible to children than those based on abstractions. Adolescents find the inductive approach to establishing a physical law easier to grasp than the deductive one. Qualitative problems involving concrete objects

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familiar to the students are readily understood, and pupils are more willing to solve them than quantitative problems. Thus, at the initial stage of physics instruction, qualitative problems play a more significant role than quantitative ones [6]. Let us examine the methodology for solving simple qualitative problems—often referred to simply as qualitative questions. When solving any physics problem, analysis and synthesis are inextricably linked. Therefore, one can speak only of a unified analytic-synthetic method for solving physics problems (including, specifically, qualitative ones).

Example 1. Are the buoyant forces acting on the same wooden block—floating first in water and then in kerosene—identical?

Solution. The buoyant force acting on a body immersed in a liquid is equal to the weight of the liquid it displaces. (A logical premise based on a known physical law.) The block floats in both liquids. (A logical premise based on the problem statement.) A body floats if its weight equals the weight of the liquid it displaces. (A logical premise based on a known physical law.) Since the same block floats in both liquids, it will displace an equal weight of liquid in each case; consequently, the buoyant forces acting on it will be identical. (A conclusion drawn from the given premises.)

Thus, the answer to the qualitative question could be obtained by synthesizing a known law (regarding the conditions for a body to float) with the problem's conditions (the body floats in both liquids).

The process of solving a qualitative question can be broken down into five stages [7]:

1. Familiarization with the problem conditions (reading the text, analyzing the diagram, examining the apparatus, etc.) and clarifying the main question (identifying the unknown and the ultimate goal of the solution).
2. Comprehension of the problem conditions (analyzing the given data and the physical phenomena described, and introducing any necessary clarifying conditions).

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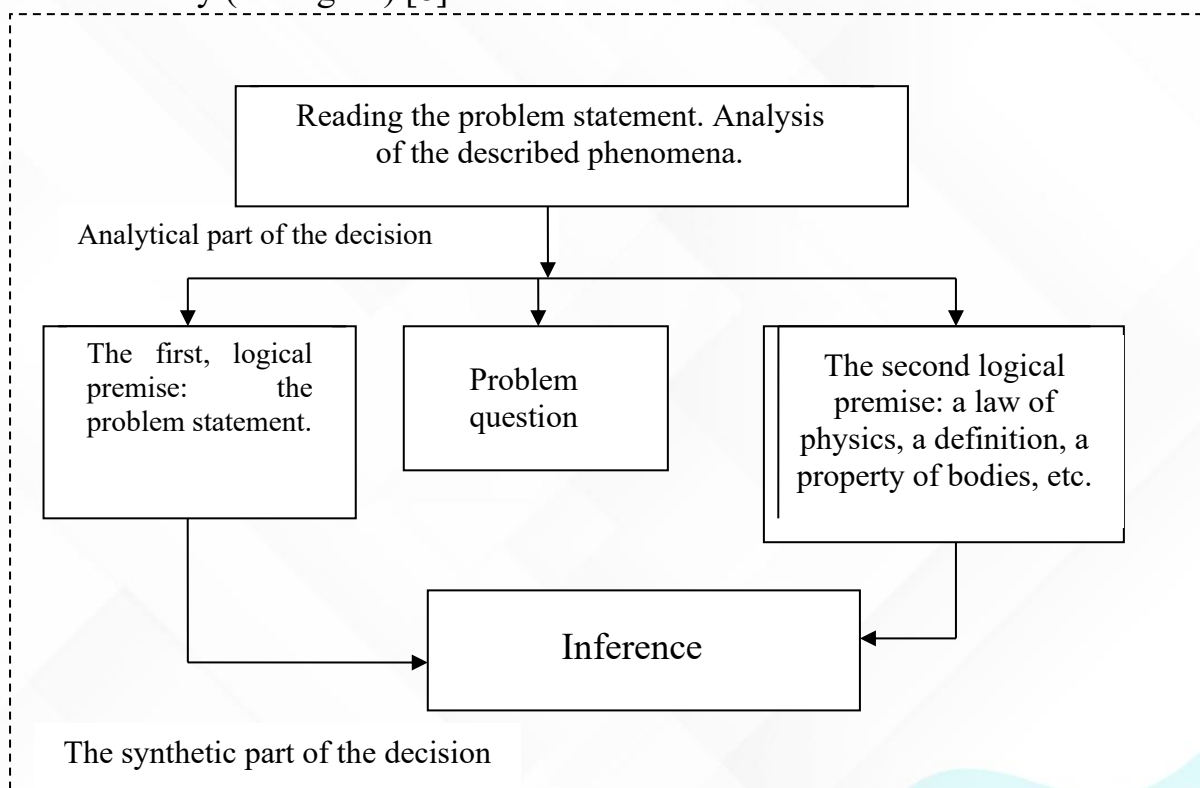


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3. Formulating a solution plan (selecting and stating the physical law or definition applicable to the problem conditions; establishing cause-and-effect relationships between the logical premises).
4. Executing the solution plan (synthesizing the problem data with the relevant law and deriving the answer to the question).
5. Verifying the answer (conducting a relevant physical experiment, solving the problem using a different method, or comparing the result with general physical principles—such as the laws of conservation of energy, mass, and charge, Newton's laws, etc.).

The methodology for solving a qualitative question can be represented schematically (see figure) [8].



In some instances, students lacking formal logical reasoning skills employ the strategy of formulating a hypothesis (intuitive thinking). This approach to problem-solving should not be dismissed. On the contrary, every proposal or

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physical concept regarding the solution must be carefully examined, and its validity or invalidity demonstrated. This process will naturally spark a discussion that fosters the development of the students' physical and logical reasoning skills.

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