NON-STANDARD LABORATORY WORKS IN PHYSICS DESIGN METHODOLOGY

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Abstract
This article analyzes the didactic essence of non-standard laboratory work in physics teaching, its design methodology, and its role in the educational process. The structure of non-standard laboratory work (goal, means, result, assessment), its differences from traditional laboratory work, and the conditions for organizing it in accordance with didactic principles are described. Scientific and practical recommendations are provided.

Keywords: Non-standard laboratory work, didactic principle, design methodology, problem, hypothesis, experiment, analysis.

Introduction

Problem statement

In the modern education system, the demand for increasing students' cognitive activity and developing independent thinking and research skills is increasing. Traditional laboratory work—often experiments based on ready-made instructions with predictable outcomes—cannot fully fulfill this task. Non-standard laboratory work deserves special attention as a pedagogical technology that encourages the student to search for the cause of the phenomenon themselves, propose a hypothesis, and verify it through experience.

Problem: A large portion of laboratory work in physics classes in Uzbekistan's secondary schools is still reproductive in nature. Students follow the available instructions and participate in experiments whose results are predetermined. This situation does not allow for the development of their scientific thinking. The insufficient development of methodologies for designing non-standard laboratory work makes this problem relevant.

Basic concepts and comparative analysis

Non-standard laboratory work — an educational and research activity that requires independent observation of a real physical phenomenon, problem-solving, hypothesis formulation, and experimental verification without showing the student a ready-made algorithm or a specific result.

The structure of such laboratory work consists of the following four components:

Component	Content
Purpose	An open question or problem to be solved by the student is expressed
Means	A list of available equipment, materials, and measuring instruments is provided.
Result	A conclusion, table, or graph formed independently by the student
Evaluation	The process is evaluated based on the validity of the hypothesis, the quality of the analysis, and the accuracy of the conclusion.

Difference from a traditional laboratory

Non-standard laboratory work differs significantly from traditional laboratory sessions in terms of content and organization. Traditional laboratory work is usually performed according to a strictly prescribed instruction, and its results are often known in advance. In such classes, the student plays the role of a performer, while the main focus is on reinforcing theoretical knowledge.

Non-standard laboratory work is organized based on problem situations and is aimed at developing students' independent thinking and research activities. In this process, a problem or task is assigned rather than a ready-made algorithm, and the result is not known in advance. As an active subject, the student conducts an experiment, analyzes it, and draws conclusions. Furthermore, such laboratory work is linked to real-life problems, especially environmental ones, and serves to develop students' practical competencies and environmental thinking.

Criterion	**Traditional laboratory**	**Non-standard laboratory**
Purpose	Approval of the law	Event discovery
Instruction	Step-by-step guide	Open question, minimal instruction
Student role	Performer	Research fellow
Result	Predictable	Unknown, to be discovered
Evaluation	Correctness of the result	Process and quality of thinking

Design based on didactic principles

To successfully design a non-standard laboratory work, the basic didactic principles of pedagogy must be fully applied:

Scientific principle. Laboratory work must be based on real physical laws and measurement methodology. The problem proposed to the student must be scientifically grounded and appropriate for their age characteristics. For example, when studying the phenomenon of surface tension, it is scientifically correct and interesting to ask an 8th-grade student about the reason for the formation of a soap film from a metal frame.

Principle of systematicity. Non-standard work should be organically linked to previously covered topics and serve to reinforce new knowledge. For example, organizing an open experiment to differentiate between the phenomena of conduction, convection, and radiation after completing the heat exchange section is a striking example of a systems approach.

The principle of consciousness and activity. The student should complete the laboratory work based on deep understanding, rather than mechanically. To do this, at the problem-solving stage, the student is required to register the idea and write a hypothesis. The combination of consciousness and activity transforms the student from a passive listener into an active researcher.

The principle of connection with life. The fact that the laboratory problem is taken from everyday life significantly increases student motivation. Questions such as 'Why did the nozzle soak up water so quickly?' or 'Does the length of the headphone wire affect the sound quality?'

arouse the student's internal curiosity and develop the ability to apply knowledge in a real-life context.

Individual approach principle. In the same laboratory setting, different students may be offered different levels of problem complexity. Strong students are given additional variables, while weak students are given guiding questions. This allows for the practical application of the principle of differentiated education in a non-standard laboratory environment.

Design Methodology

The methodological basis for designing non-standard laboratory work is the consistent application of the following five mandatory components:

Component 1 - Problem. The problem is expressed in the form of a question that is independently perceived by the student, has no clear answer, and is verified through experience. It must satisfy three criteria: a) practical context; b) the presence of measurable variables; c) compliance with the student's level of knowledge. Example: 'How does the magnetic force depend on the metal mass of the axe?'

Component 2 - Hypothesis. The student writes their hypothesis for the problem in the formula 'if... then...'. The formulation of a hypothesis is the most critical stage of cognitive activity, forcing the learner to reflect in advance. At this stage, the teacher does not evaluate the correct or incorrect hypothesis - what matters is whether the hypothesis is scientifically grounded or not.

Component 3 - Experiment. The student independently draws up an experimental plan to test their hypothesis: identifies the necessary tools, develops a method for controlling variables, and designs a measurement table. The role of the teacher is limited to the role of the instructor. Compliance with safety requirements during the experiment remains under pedagogical supervision.

Component 4 - Analysis. The student organizes the obtained data into a table, graph, or mathematical expression and compares it with the original hypothesis. At the analysis stage, the student evaluates the errors and inaccuracies themselves: the accuracy of the measuring instrument, external influences, and the necessity of repeated measurements are discussed.

Component 5 - Conclusion. A conclusion contains a clear statement about the validity or invalidity of a hypothesis. The student is required to link the result with future applications and existing scientific knowledge. This stage provides an opportunity for metacognitive reflection: "What have I learned? Where did I go wrong? What other experiments could have been conducted?'

Design example

Below is an example of a non-standard laboratory work developed for the 9th grade physics course (optics section):

Stage	**Content**
Subject	What does the refractive index of light depend on?
Problem	Is the refractive index of light different in different liquids, and what does it depend on?
Hypothesis	It can be assumed that if the density of a liquid increases, then the refractive index also increases.
Tools	Semiconductor laser, graduated protractor, water, salt solution, glycerin, glass.
Experiment	The angle of incidence and refraction are measured by applying laser beams to various liquids; n = sin (α) /sin (β) is calculated using the formula.
Analysis	The results are entered into a table; a graph of the density and refractive index is drawn.
Conclusion	Hypothesis partially confirmed: as density increases, n increases, but not proportionally. New question: what is the effect of molecular structure?

Conclusion

The methodology for designing non-standard laboratory work is a reliable pedagogical tool for ensuring qualitative changes in physics education. Summarizing the approach based on this article, the following conclusions can be drawn:

- Non-standard laboratory work moves the student from passive performance to active research and forms a culture of scientific thinking.
- Problem → Hypothesis → Experiment → Analysis → Conclusion The structure represents a simplified model of scientific methodology suitable for the reader.
- Didactic principles (scientific, systematic, conscious, connected with life, individual approach) form the methodological foundation of designing these works.
- Combining traditional and non-standard laboratory work is the most optimal pedagogical strategy, as they complement each other.
- For the widespread introduction of non-standard laboratory work, it is necessary to conduct special training for teachers, develop appropriate methodological manuals, and update assessment criteria.

Future research:

It is advisable to conduct empirical research on the integration of non-standard laboratory work in STEM education, its application in a digital laboratory environment (virtual laboratory), and its integration into the formative assessment system.

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