

## IMPROVING THE METHODOLOGY OF TEACHING MOLECULAR PHYSICS IN SCHOOLS BASED ON NON-STANDARD TASKS

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### **Abstract**

This article will develop a methodology for using non-standard assignments in the process of teaching molecular physics in general secondary schools, and its impact on educational results will be assessed on an empirical basis. The purpose of the study is to identify didactic mechanisms that enhance the competencies of modeling microunion phenomena in students, making logical conclusions and interpreting experimental information.

### **Keywords**

molecular physics; nonstandard tasks; competency-based approach; modeling; formative assessment; quasi-experiment.

### **Introduction**

In general secondary education, the section of molecular physics is considered a basic content that serves to explain natural phenomena to students through microscopic representations. However, practice shows that in this section, many students are unable to establish a stable connection between macroscopic observation and the particle model, and the use of formulas often remains at the level of mechanical calculation. This situation is explained, on the one hand, by the abundance of abstract concepts, and on the other hand, by the fact that the task system relies on the same type of algorithmic problems. From a didactic perspective, educational tasks must compel the student not only to work with a ready-made rule but also to select a model, make assumptions, argue, and interpret the result. International studies have noted that inquiry and model-based approaches are effective in strengthening conceptual understanding, argumentation, and transfer skills in problem situations when studying physics [1; 2]. Physics teaching methodology requires a high level of preparation, pedagogical skills, and innovative approaches from teachers. It is important to equip students not only with theoretical knowledge but also with practical skills through the extensive use of laboratory equipment and modern technologies in lessons [3]. At the same time, in the methodology of physics in Soviet schools, the deterministic

orientation of the problem set and textbook text, as well as the focus of assessment on the final result, are criticized for failing to reveal the student's thinking process [4]. In the context of schools in Uzbekistan, the practical application of the competency-based approach, especially in sections requiring modeling such as molecular physics, is linked to the problem of designing appropriate educational tasks [5]. Therefore, the methodologically grounded inclusion of non-standard tasks in the educational process is relevant, as they encourage the student to work with various representations, real information, and restrictive conditions. The aim of this study is to develop a methodology for teaching molecular physics in secondary schools based on non-standard tasks and to empirically evaluate its effectiveness. The tasks were defined as follows: first, to define and classify the didactic functions of non-standard tasks for the content of molecular physics; second, to create a learning scenario that sequentially organizes tasks into thematic blocks; third, to develop assessment rubrics based on competency indicators; fourth, to conduct a quasi-experimental study of the impact of the proposed methodology on conceptual understanding and transfer skills. Scientific novelty is seen in three directions: non-standard tasks are divided into three functional types in molecular physics, each of which triggers a specific sequence of cognitive actions; the task system is integrated with formative assessment mechanisms; when interpreting results, not only test scores are measured, but also the quality of explanation and the adequacy of the model. The practical significance lies in providing the teacher with a ready-made methodological construction for lesson planning, differentiated classroom work, and diagnosing student difficulties. The study was based on a mixed methodology, as the impact of non-standard tasks is manifested not only in final results but also in the student's thinking process. The empirical part was organized in a quasi-experimental design: two parallel 9th-grade groups were selected, one of which was designated as the experimental group and the other as the control group. The groups were approximated based on the students' physics performance in the previous quarter and the results of the diagnostic entrance test. The intervention took the form of an eight-week module and covered topics such as the basics of molecular-kinetic theory, ideal gas laws, internal energy, and heat exchange. In the control group, lessons were conducted based on the current textbook and the sequence of standard problems, while in the experimental group, a non-standard task bank was used for each topic block.

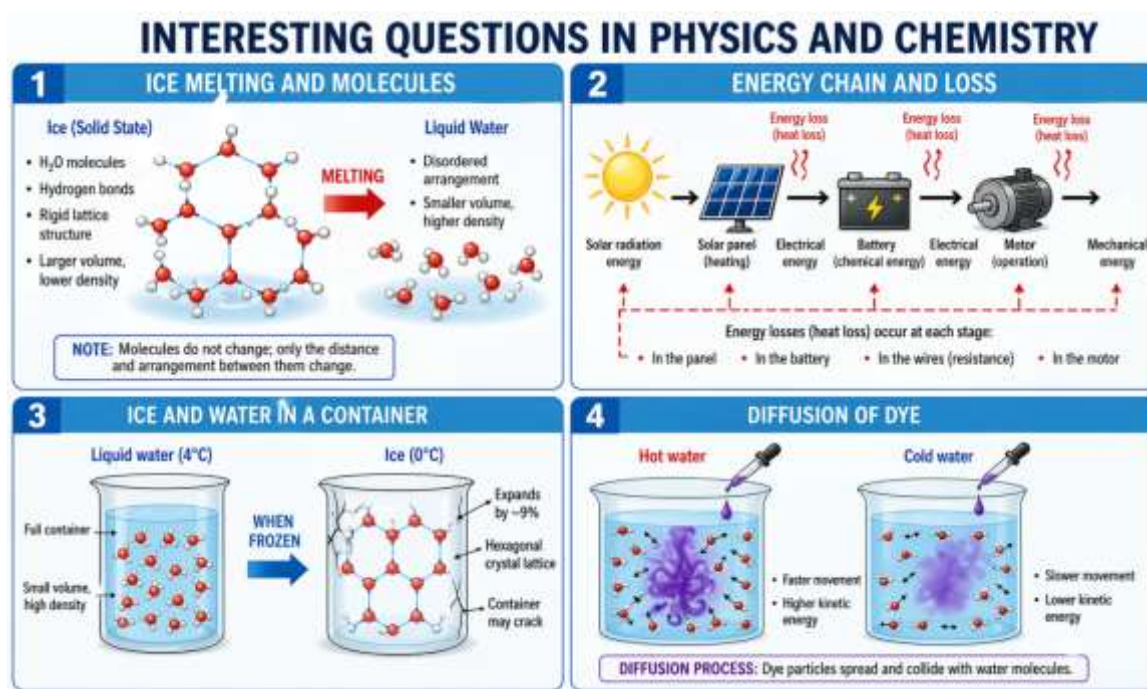


Figure 1.

**Non-standard assignment questions:**

**Question 1:** Why is the statement "When ice melts, its molecules also melt and shrink" incorrect? How does the distance between particles change?

**Question 2:** How does energy change in the solar panel → battery → motor circuit? At what point can energy be "waste"?

**Question 3:** Water in a closed glass container burst when it froze. How does the molecular structure of water change when it freezes?

**Question 4:** Explain the dispersion of paint dripped into water at the micromodel level. Why does the paint dissolve faster in hot water?

In the diagnostic test, the mean values of the experimental and control groups were close, and the difference was not statistically significant; this indicates a balanced level of preparation of the groups at the beginning of the intervention. At the end of the eight-week module, the experimental group significantly increased its average score based on conceptual testing results; an increase was also recorded in the control group, but the growth rate was lower. In particular, the experimental group showed superior results in items requiring the selection of a micromodel and the correlation of quantities such as pressure, temperature, and internal energy with the particle interpretation. In particular, students were more inclined to explain the proportionality in the ideal gas laws outside the formula, through the number of molecules, collision frequency, and average kinetic energy. At the same time, in our context, it was of particular importance that the assessment of non-standard tasks was carried out through a rubric, as this approach directed the student not only to the "correct answer," but also to "correct thinking and

explanation." This, in turn, somewhat mitigates the problem of linking the practical criteria of the competency-based approach to the content of the discipline [5].

First, the quasi-experimental design does not provide complete randomization, so generalizing the results directly to all schools requires caution. Second, because the intervention was limited to an eight-week module, the long-term impact and transfer to subsequent departments were not thoroughly examined. The third limitation is that the quality of non-standard assignments depends on the teacher's facilitation skills, and the stability of the methodology is higher when combined with the teacher training system. Future research should be aimed at assessing the scalability of the methodology through the adaptive presentation of the task bank on a digital platform, automated rubric elements, and classroom communication analysis.

The study showed that the methodology based on non-standard tasks in teaching molecular physics in secondary schools strengthens conceptual understanding and the ability to transfer knowledge to new situations. In the developed approach, non-standard tasks are divided into conceptual-diagnostic, information-based, interpretive, and constructive problem types, and they are arranged based on sequential complexity across thematic blocks. Rubric-based assessment strengthened formative management by making the quality of students' model selection, argumentation, and physical interpretation more visible. Empirical results noted a steady increase in the components of micro-macro correlation interpretation, argumentation, and error interpretation in the experimental group. This methodology allows teachers to plan a lesson in harmony with competence indicators and to substantially identify student difficulties. Above, 4 questions were given for thoughtful answers. Unable to display image in the standard lesson process. During the non-standard lesson, along with the questions, we included a picture that encourages students to think. Table 1 presents the results.

**Table 1. Lesson results.**

<b>Answer Options</b>	<b>Standard Lesson</b>	<b>Non-standard Lesson</b>
<b>Correct answers</b>	1	3
<b>Incorrect answers</b>	3	1

The table compares student performance in standard and non-standard lessons. It shows that in a standard lesson, students tend to have fewer correct answers (1) and more incorrect answers (3). In contrast, during a non-standard lesson, students achieve more correct answers (3) and fewer incorrect answers (1).

This suggests that non-standard teaching methods are more effective in improving students' understanding and learning outcomes.

### Conclusion

This article demonstrates that teaching methods for teaching physics in general secondary schools based on non-standard tasks are much more effective. Using non-standard tasks in teaching molecular physics significantly enhances not only students' theoretical knowledge but also their ability to model micro-world phenomena and logical thinking. The research results indicate that such didactic mechanisms are more effective than traditional methods in forming students' practical competencies.

### REFERENCES:

1. Hestenes D., Wells M., Swackhamer G. Force Concept Inventory. The Physics Teacher. College Park, American Association of Physics Teachers, 1992, 30(3), 141–158.
2. Driver R., Asoko H., Leach J., Mortimer E., Scott P. Constructing Scientific Knowledge in the Classroom. Educational Researcher. Washington, American Educational Research Association, 1994, 23(7), 5–12.
3. Xujanov E.B. Mutaxassislik fanlarini o'qitish metodikasi / Darslik / Toshkent: "Zuxro baraka biznes" , 2025.-331 b.
4. Перышкин А. В. Физика. 7–9 классы: учебник. Москва, Дрофа, 2019. 320 с.
5. To'raqulov O. A., Abdullayev B. T. Fizikani o'qitish metodikasi. Toshkent, O'zbekiston, 2018. 352 b.
6. Bloom B. S. Taxonomy of Educational Objectives. Handbook I: The Cognitive Domain. New York, David McKay Company, 1956. 207 p.