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IMPROVING THE METHODOLOGY OF TEACHING CHEMISTRY IN THE PROCESS OF PREPARING SCHOOL STUDENTS FOR PISA ASSESSMENT PROGRAMS

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Annotation: This article presents general information about PISA tests and their significance in the education system. It also analyzes the role and importance of the PISA assessment framework in improving the methodology of teaching chemistry. The article highlights modern teaching methods used to enhance the effectiveness of chemistry education and their role in developing students' critical and scientific thinking skills. In addition, practical recommendations are provided to increase the efficiency of chemistry teaching methodologies in preparing students for PISA assessments.

Keywords: PISA, assessment criteria, scientific literacy, competence, PBL, cross-disciplinary approach, interactive methods, innovative technologies, critical thinking, practical skills, laboratory work, virtual simulators, integration, scientific analysis, learning outcomes.

Introduction:

PISA (Programme for International Student Assessment) is an international evaluation program aimed at assessing students' literacy in reading (text comprehension), mathematics, and science. It is designed to determine how well students can apply the knowledge and skills acquired at school to real-life situations [1]. A distinctive feature of the PISA program is that it does not fully replicate the curriculum of any specific country. Therefore, it is difficult to link PISA tasks to a particular grade level or topic: one part of a task may relate to a certain subject taught in one grade, while another part may correspond to a different grade or discipline. In many cases, the tasks are structured in an integrated manner. For this reason, teachers are advised to explain each PISA question by connecting it with the relevant curriculum topics [2].

The Programme for International Student Assessment (PISA) today serves as a key tool for evaluating educational effectiveness and comparing education systems across countries worldwide. In Uzbekistan, there is a growing need to analyze PISA test results, study them in depth, and identify strategies to prepare students in primary and secondary education for this international assessment. From this perspective, PISA outcomes are considered a fundamental source for assessing the quality of education, improving curricula, and developing effective pedagogical strategies [3].

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Global studies on PISA effectiveness also confirm the importance of reforms in this area. For example, research conducted by S. Park and J. Li (2018) analyzed global trends in the PISA program and emphasized the direct impact of educational policy and teaching methodology on students' performance in international assessments [4].

In this study, special attention is given to improving the methodology of teaching chemistry in accordance with PISA requirements. Methodological approaches such as practical laboratory work, interactive learning materials, and the use of modern technologies were examined. Furthermore, to develop students' scientific thinking and their ability to apply knowledge in problem-based situations, the following methodologies were found to be effective:

— Practical laboratory work — allows students to observe and analyze chemical processes;

— Problem-Based Learning (PBL) — develops critical thinking through solving real-life problems;

— Cross-disciplinary approaches — highlight the interconnections between chemistry, biology, and physics;

— Modern technologies — strengthen students' practical skills through the use of simulators and interactive platforms.

Acid Rain. The photograph below shows the Caryatid statues, which were built 2,500 years ago on the Acropolis in Athens. These statues were made of marble — a rock composed mainly of calcium carbonate ($CaCO_3$). In 1980, the original statues were replaced with replicas and moved to the Acropolis Museum in Athens, as the originals had deteriorated due to atmospheric effects. The primary cause of this deterioration was the impact of acid rain.

Ordinary rain naturally has a slightly acidic environment because it absorbs carbon dioxide (CO_2) from the air. However, when sulfur oxides (SO_2, SO_3) and nitrogen oxides (NO, NO_2)

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dissolve into rainwater, they react with water to form sulfuric and nitric acids. As a result, the pH level of the rain decreases further, turning it into acid rain.

Question:

Where do sulfur and nitrogen oxides in the atmosphere come from?

Assessment criteria:

To answer this question correctly, students must understand the physical and chemical properties of carbon dioxide, nitrogen, and sulfur oxides, their solubility in water, and the main sources of their emission into the atmosphere. Students are expected to provide one or more of the following scientifically accurate answers:

From waste gases produced by the combustion of coal, natural gas, and oil;

From smoke emissions of factories, plants, and power stations;

From exhaust gases released by vehicle engines;

From volcanic activity releasing gases into the atmosphere.

These responses are considered complete and scientifically valid (1 point). The following answers are incomplete or incorrect and therefore receive 0 points:

“Released from plastics”;

“Naturally part of the air composition”;

“From coal and oil” (without mentioning the combustion process);

“From nuclear power plants”;

“From industrial waste” (too vague and lacks specificity).

This task is aimed at assessing students’ competence in scientifically explaining phenomena, as well as evaluating their environmental awareness and ability to apply chemical knowledge in real-life contexts.

Is It Dangerous for Health?

Imagine you live near a large chemical plant that produces fertilizers for agriculture. In recent years, several chronic respiratory diseases have been recorded among residents in this area. Local people believe this situation is related to toxic fumes emitted from the plant. As a result, a community meeting was organized where scientists presented their conclusions.

Conclusion of scientists affiliated with the chemical company:

“We examined the level of soil contamination in the local area. The analysis results showed no presence of toxic chemicals.”

Conclusion of independent scientists invited by the local community:

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"We compared the number of people suffering from respiratory diseases living near the chemical plant with those living farther away. As a result, it was found that such diseases were significantly more common among those living close to the plant."

Question:

The owner of the chemical plant, relying on the conclusion of affiliated scientists, stated that "the fumes from the plant do not pose a threat to the health of local residents."

Provide one reason that raises doubt about the validity of the plant owner's statement (the answer should differ from the independent scientists' conclusion).

Assessment Criteria:

This task requires students to demonstrate deep understanding of the text, analyze differing scientific conclusions, and apply critical thinking to form a logical argument.

If a student provides one logically reasoned cause for doubt regarding the conclusion of the affiliated scientists, the answer is considered complete (1 point).

Correct answers may include:

The substances causing respiratory diseases may be present in the air, not in the soil;

Toxic substances might have decomposed over time, becoming harmless in the soil;

It is unclear whether the soil samples were taken directly from the area near the plant;

The scientists may have financial interests in the plant or concealed the analysis results;

The research methods might not have been comprehensive or scientifically reliable enough.

If no such reasoned argument is provided or the response is irrelevant to the topic, it is not accepted (0 points).

This task is aimed at developing students' competence in analyzing data and evidence scientifically, practicing critical thinking, and assessing the reliability of conclusions.

Question 2

The independent scientists invited by the concerned local residents compared the number of people suffering from chronic respiratory diseases living near the plant with those living far from it.

Question:

Write one differing factor between these two areas that may lead you to think that such a comparison might not be a fully reliable piece of evidence.

Assessment Criteria:

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This task requires students to demonstrate analytical and critical thinking skills. Since the comparison is based only on the number of patients, other factors that could affect the reliability of the study must also be considered.

If students identify other differing factors between the two areas that may influence health conditions, the answer is considered complete (1 point).

Correct answers may include:

The population size near the plant and in the distant area may differ;

The quality of medical services may be better in one area than in the other;

There may be differences in the age composition or demographics of the populations;

Other sources of air pollution might exist in the distant area;

Climatic or geographical conditions of the regions may affect health differently.

If the answer does not include such logically reasoned points or is irrelevant to the topic, it is not accepted (0 points).

This task aims to develop students' competencies in designing scientific research, evaluating results, and analyzing evidence.

Results:

In the process of improving chemistry teaching methodology, students' critical thinking abilities and scientific analysis skills significantly improved. Through the Problem-Based Learning (PBL) methodology and laboratory experiments, students learned to apply their knowledge to solve real-life problems. For instance, while studying chemical reactions and their practical applications, students were provided with opportunities to explore these processes experimentally. As a result, they not only memorized information but also developed skills in independent analysis, synthesis, and practical application.

The following table and graph illustrate the results of students' scientific literacy achieved over three stages of assessment.

Table 1.

Class	Type 1 (Traditional Test)	Type 2 (Non-Traditional Tests)	Type 3 (PISA Test)
7-A	56%	40%	32%
7-B	55%	30%	28%
7-V	54%	42%	30%
7-G	57%	50%	30%

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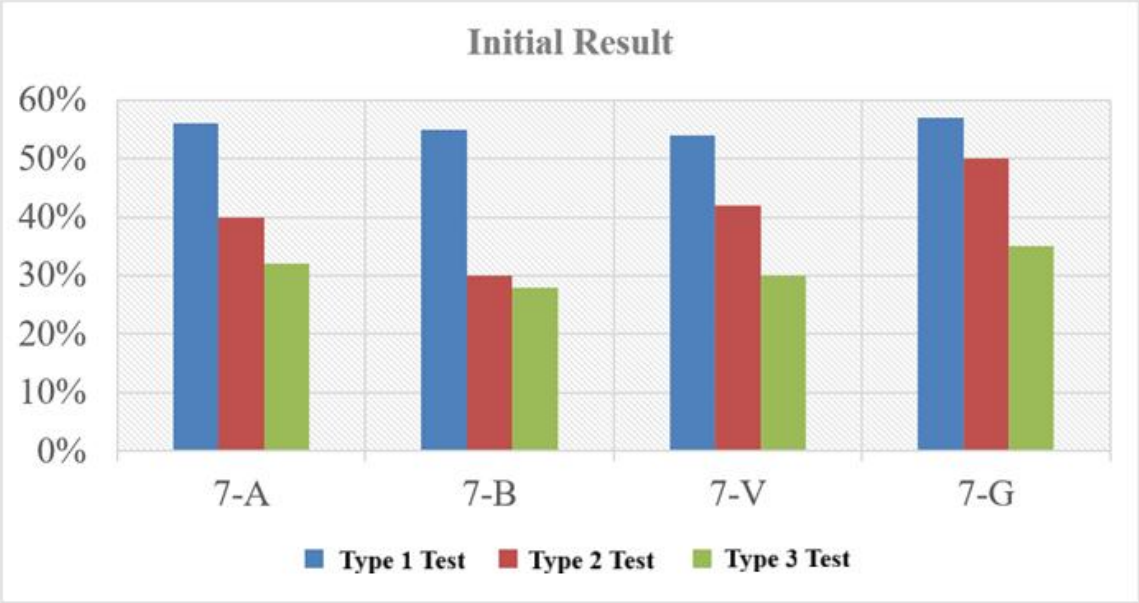

Diagram 1

Modern technologies, such as online simulators and interactive learning programs, have enabled chemistry lessons to become more engaging, effective, and practice-oriented. Through virtual laboratories, students can safely conduct and analyze chemical reactions while observing results in real time. This approach has enhanced their scientific reasoning, logical thinking, and problem-solving skills, playing a key role in preparing them to meet the requirements of the PISA assessment system. Consequently, students' initial evaluation results improved significantly, with noticeable growth in their interest in chemistry and practical analytical abilities.

Table 2.

Class	Type 1 (Traditional Test)	Type 2 (Non-Traditional Tests)	Type 3 (PISA Test)
7-A	60%	55%	45%
7-B	66%	45%	36%
7-V	63%	51%	40%
7-G	69%	62%	50%

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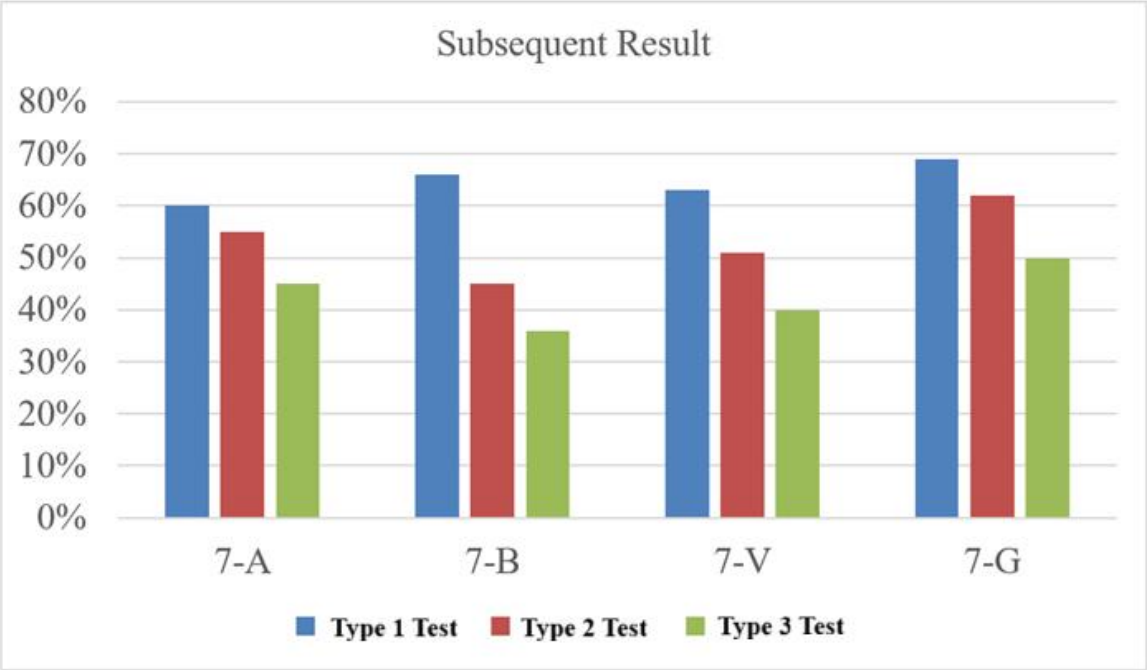

Diagram 1

Discussion.

In the process of improving the methodology of teaching chemistry, it is emphasized that students should not only memorize knowledge theoretically but also be able to apply it in practice. This is because PISA tests assess not only students' theoretical knowledge but also their practical, analytical, and critical thinking skills. Therefore, in chemistry education, practical experiments, laboratory work, and problem-based activities play a crucial role.

Introducing students to real-life problems, teaching them to analyze chemical processes, and apply various approaches help deepen their scientific thinking. This, in turn, enhances students' ability to think independently, draw logical conclusions, and solve problems during PISA test preparation.

The Problem-Based Learning (PBL) methodology plays an important role in developing students' critical and creative thinking. Through this method, learners acquire skills in scientific analysis, experimentation, and result evaluation while solving problems. This approach enables a deeper understanding of chemistry, promotes reasoning based on experimentation, and aligns learning outcomes with global education standards.

Moreover, cross-disciplinary approaches (interdisciplinary integration) help students understand the connections between chemistry and other subjects such as biology, physics, ecology, or mathematics. Since most PISA tasks require the application of interdisciplinary knowledge, integrating chemistry education with other natural sciences fosters students' abilities in comprehensive analysis, logical reasoning, and scientifically grounded decision-making.

Conclusion.

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Improving the methodology of teaching chemistry in preparing school students for PISA assessments is an essential factor in developing their scientific thinking, analytical reasoning, and practical skills. Through the enhanced methodology, students not only acquire theoretical knowledge but also gain the ability to apply it in solving real-life problems.

The research results indicate that the use of modern teaching methods, virtual laboratories, and the Problem-Based Learning (PBL) methodology increases students' interest in the subject and strengthens their critical and scientific thinking abilities in accordance with the requirements of the PISA assessment system.

This study was conducted among students of grades 7-A, 7-B, 7-V, and 7-G at School No. 30 in Bo'stonliq District, Tashkent Region. The analysis of the initial and final test results demonstrated that the new methodological approaches significantly improved students' knowledge levels, enhanced their ability to analyze chemical processes, draw conclusions, and think scientifically.

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