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DEVELOPMENT OF METHODOLOGY FOR SOLVING PHYSICS PROBLEMS

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Abstract: *This article analyzes the issues of developing methodologies for solving physics problems in the process of teaching physics. The study identifies the shortcomings of traditional approaches to solving physics problems and proposes a step-by-step, logical, and competency-based methodology. The results of the pedagogical experiment demonstrate that the proposed methodology is effective in developing students' independent thinking, ability to apply theoretical knowledge in practice, and analytical reasoning skills.*

Keywords*:* *physics education, problem solving, methodology, pedagogical technologies, competence.*

INTRODUCTION

In the context of globalization and rapid scientific and technological development, modernizing the education system and forming students' abilities for independent thinking, analytical reasoning in problem situations, and making informed decisions have become pressing tasks. In this process, the role of natural sciences, particularly physics, is invaluable.

Physics is a fundamental science that studies the laws of nature and serves to develop students' scientific worldview, understanding of cause-and-effect relationships, and skills for applying theoretical knowledge in practice. In particular, problem solving in physics is an important didactic tool for reinforcing knowledge, developing logical thinking, and deeply mastering theoretical concepts.

However, educational practice shows that solving physics problems is often limited to mechanical memorization of formulas and repetition of standard tasks. This situation leads to superficial understanding of subject content and insufficient development of independent thinking skills. Therefore, scientifically improving the methodology of solving physics problems is considered a relevant pedagogical issue.

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LITERATURE REVIEW

In recent years, with the development of digital education and innovative pedagogical technologies, approaches to teaching physics problem solving have changed significantly. Researchers increasingly interpret problem solving not merely as a computational activity but as a complex cognitive process involving analysis, generalization, modeling, and drawing conclusions.

Modern scientific literature extensively discusses problem-solving methodologies based on the constructivist approach. According to this approach, knowledge is not transmitted in a ready-made form but is constructed independently by learners. Physics problems act as a key tool for activating this process. Studies indicate that problem-solving activities organized according to constructivist principles positively affect students' long-term knowledge retention.

Scientific works related to the metacognitive approach also deserve special attention. Within this framework, students develop skills for monitoring their own thinking processes, identifying errors, and correcting them during problem solving. Applying this approach to physics problems enhances students' readiness for independent learning.

Analysis of the reviewed literature shows that while certain aspects of problem-solving methodology have been studied in depth, the integration of competency-based, metacognitive, and practical approaches into a unified methodological system has not been sufficiently addressed. This article attempts to fill this research gap.

RESEARCH METHODS

This study is aimed at improving the methodology of solving physics problems based on modern pedagogical approaches, including competency-based, constructivist, and metacognitive frameworks. The selection of research methods was grounded in theoretical perspectives proposed in national and international literature on physics education, particularly problem-based learning, step-by-step instruction, and active learning strategies.

At the theoretical stage, analysis of scientific and pedagogical literature played a central role. The historical development of physics problem-solving methodologies, as well as the didactic potential of traditional and innovative approaches, was examined. Methods of analysis, synthesis, induction, and deduction were applied, enabling the development of a theoretical model for problem-solving methodology.

Pedagogical observation was systematically used throughout the study to assess students' activity during problem solving, their ability to make independent decisions, draw logical conclusions, and apply physical concepts in practical situations. The observation results served as an important source for identifying existing problems and substantiating methodological solutions.

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The comparative method was a key tool at the empirical stage. It was used to compare the effectiveness of traditional problem-solving approaches with the proposed step-by-step methodology. Indicators such as the level of knowledge acquisition, speed and accuracy of problem solving, and analytical and critical thinking skills were considered.

The main empirical method was a pedagogical experiment conducted at 17th General Secondary Education School and 18th General Secondary Education School. Participants were divided into experimental and control groups. In the experimental groups, problem solving was organized through problem-based situations and a step-by-step algorithmic approach, while traditional methods were applied in the control groups.

Students' knowledge levels were assessed using diagnostic tests, written assignments, and oral questioning. Evaluation criteria included problem analysis, construction of physical models, selection of appropriate laws and formulas, and justification of results, allowing a comprehensive assessment of problem-solving competence.

Mathematical and statistical analysis methods were used to process empirical data. Results were summarized using percentage indicators and mean values, ensuring the reliability and objectivity of the findings.

Reflective and metacognitive analysis methods were also employed to examine students' abilities to evaluate their own learning activities, identify errors, and eliminate them during problem solving. This approach contributed to enhancing students' readiness for independent learning.

Overall, the selected set of research methods ensured the reliability of the scientific conclusions and fully corresponded to the objectives of the study.

RESULTS AND DISCUSSION

To determine the effectiveness of the developed methodology for solving physics problems, pedagogical experimental work was conducted in accordance with competency-based, step-by-step, and metacognitive approaches.

The experiment was carried out at 17th General Secondary Education School and 18th General Secondary Education School. Students were divided into experimental and control groups, taking into account their initial knowledge levels, academic performance, and age characteristics.

The experiment was conducted in three stages: initial, intermediate, and final.

At the initial stage, students' existing knowledge and skills in solving physics problems were assessed using diagnostic tests and written assessments. The results showed that the initial achievement levels of the experimental and control groups were nearly identical.

During the intermediate stage, the experimental group was taught using the developed methodology, emphasizing step-by-step analysis, modeling of

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physical processes, and independent thinking. Traditional teaching methods were applied in the control group.

At the final stage, students' knowledge levels, problem-solving speed, and accuracy were reassessed. The results indicated significant positive changes in the experimental group (Figure 1).

Graphical analysis shows that the knowledge acquisition level in the experimental group increased from 51% at the initial stage to 78% at the final stage, whereas in the control group it increased from 52% to only 63%. This difference clearly demonstrates the effectiveness of the proposed methodology.

Positive improvements were also observed in students' abilities to analyze problems, consciously select physical laws, and justify results. Additionally, students in the experimental group showed increased interest in complex and non-standard problems.

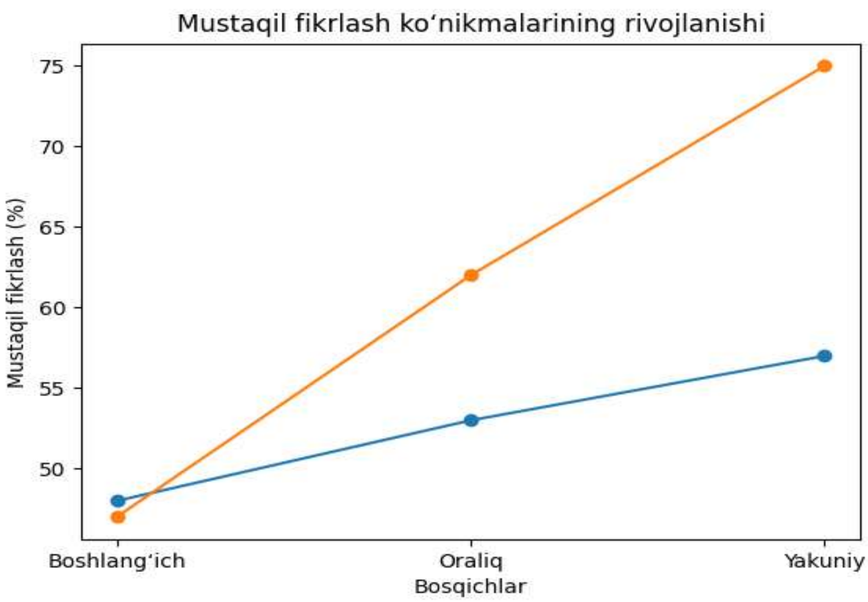

Figure 1. Changes in Knowledge Levels

The results were summarized using mathematical and statistical analysis and were found to fully correspond to the research objectives.

Graphical data reflecting the development of independent thinking skills also have significant scientific value. In the experimental group, independent thinking levels reached 75% at the final stage, while in the control group this indicator did not exceed 57% (Figure 2).

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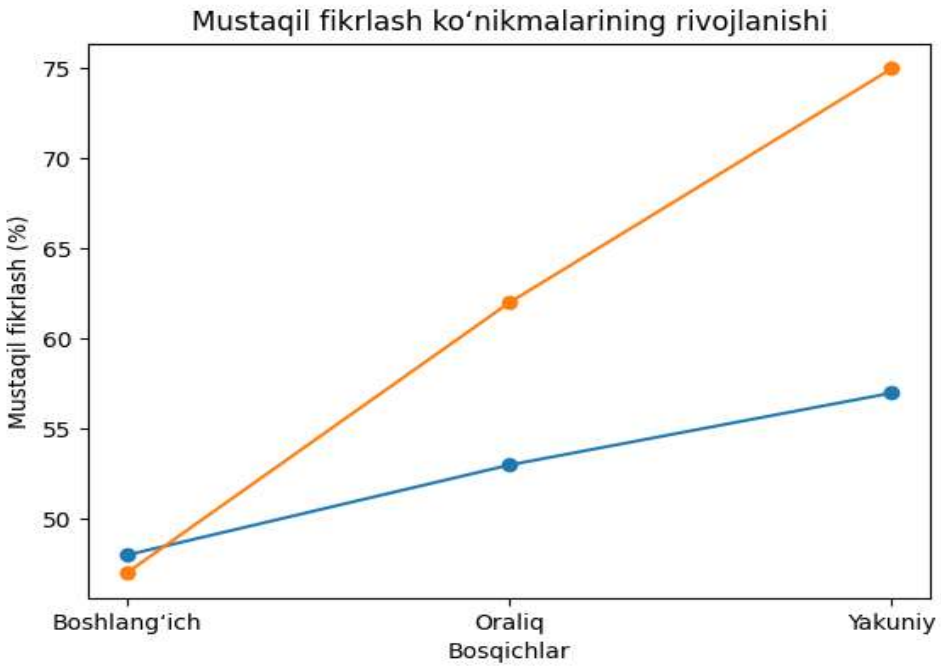

Figure 2. Development of Independent Thinking Skills

A reduction in the number of errors made during problem solving was also observed, indicating the effectiveness of an approach focused on meaningful application of formulas rather than mechanical memorization. These findings are consistent with the conclusions of P. Heller, E.F. Redish, and other researchers.

Overall, the experimental results show that the proposed methodology not only improves academic performance but also positively influences students' attitudes toward learning and increases their interest in complex and non-standard problems.

CONCLUSION

The results of the pedagogical experiment demonstrate that organizing physics problem solving through a step-by-step, logical, and competency-based approach significantly improves students' conscious knowledge acquisition. The higher outcomes achieved by the experimental group scientifically confirm the greater effectiveness of the proposed methodology compared to traditional teaching methods.

Positive changes in students' independent thinking, analytical skills, and ability to justify results indicate that the methodology contributes to the development of practical and intellectual competencies. The reduction in problem-solving errors further confirms the effectiveness of meaningful and purposeful use of formulas.

The findings highlight the importance of incorporating problem-based situations, modeling, and reflective analysis in physics education. The developed methodology increases students' interest in physics and fosters

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creative approaches to solving complex problems.

Overall, the proposed methodology for solving physics problems is scientifically grounded, practically effective, and fully aligned with modern competency-based educational requirements. Its implementation in secondary and higher education institutions can improve the quality of physics education and provide a solid foundation for future research.

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