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ENHANCING THE DIDACTIC EFFECTIVENESS OF TEACHING PHYSICS BASED ON PROBLEM-BASED LEARNING

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ABSTRACT

This thesis addresses the theoretical and methodological foundations for increasing the effectiveness of teaching physics in general education schools through problem-based learning (PBL) technologies. Based on an analysis of recent international scientific studies, it substantiates the potential of this technology to develop higher-order thinking, critical thinking, and student motivation. Furthermore, the author presents the experimental research design, methodological developments, and assessment tools conducted within the study. This research serves as a practical basis for enhancing the didactic effectiveness of PBL methodologies in teaching physics in general education schools.

KEYWORDS: Problem-based learning technologies, general education school, physics teaching, didactic effectiveness, critical thinking, higher-order thinking, motivation.

INTRODUCTION

At present, applying methods that stimulate students' engagement, develop higher-order thinking, critical analysis, and problem-solving skills remains a pressing task within the education system. International studies have recognized problem-based learning (PBL) technologies as an approach that effectively addresses these needs. A meta-analysis conducted by Asrizal et al. [1] demonstrates that PBL has significant effectiveness in the sciences, particularly in physics education. Likewise, Liu, Mustakim, and Muhamad [2] have substantiated the advantages of PBL in fostering critical thinking skills.

At the same time, several studies are being carried out in our country in this area. For instance, in a study conducted at the Nizami Tashkent State Pedagogical University, Sharipova Sabokhat [3] analyzed ways to enhance students' thinking and creative capacity through creativity-focused and problem-based learning methods. Her work shows that lessons organized around problem-based tasks motivate students to engage in independent inquiry and increase their interest in learning. Researchers at Jizzakh State Pedagogical Institute have developed physics lessons using PBL-STEM integrated student worksheets, empirically demonstrating their role in improving students' problem-solving abilities regarding temperature and heat topics [4].

Based on this, the present study aims to develop a methodology for applying problem-based learning (PBL) in the context of general education schools. The main objective of the research is to establish methodological foundations that serve to improve students' knowledge, skills, competencies, and motivation through the use of PBL technologies in teaching physics at general education schools.

The core issue is that traditional teaching methods often fail to sufficiently develop students' independent inquiry activities, collaborative work skills, and practical thinking abilities, which

in turn reduces didactic effectiveness [5]. A study conducted by Smith et al. [6] statistically substantiated the effectiveness of problem-based learning technologies in developing conceptual understanding within the topic of "Mechanical Waves." In their work, students' knowledge levels were assessed using pre- and post-tests, and the results demonstrated the advantages of PBL technologies over traditional methods.

Studies carried out in the Uzbek context complement these international experiences: at Tashkent State Pedagogical University (TSPU) and other research centers, PBL-based activities have been recognized as an effective tool for enhancing students' motivation, shaping them into active participants during lessons, and fostering their scientific and creative potential. Therefore, the methodology developed in this study is proposed not only with reference to international experience but also adapted to the national context.

In the course of our research, experimental studies were conducted during the 2024–2025 academic year in six general education schools across Uzbekistan. A total of 12 classes (324 students) participated in the study. In the experimental group, lessons were organized based on problem situations, group discussions, and independent inquiry, while in the control group, lessons were conducted using traditional methods.

Throughout the experiment, students' active participation, collaboration in group work, and engagement in developing independent solutions were examined using observation charts and teacher records.

Assessment tools included:

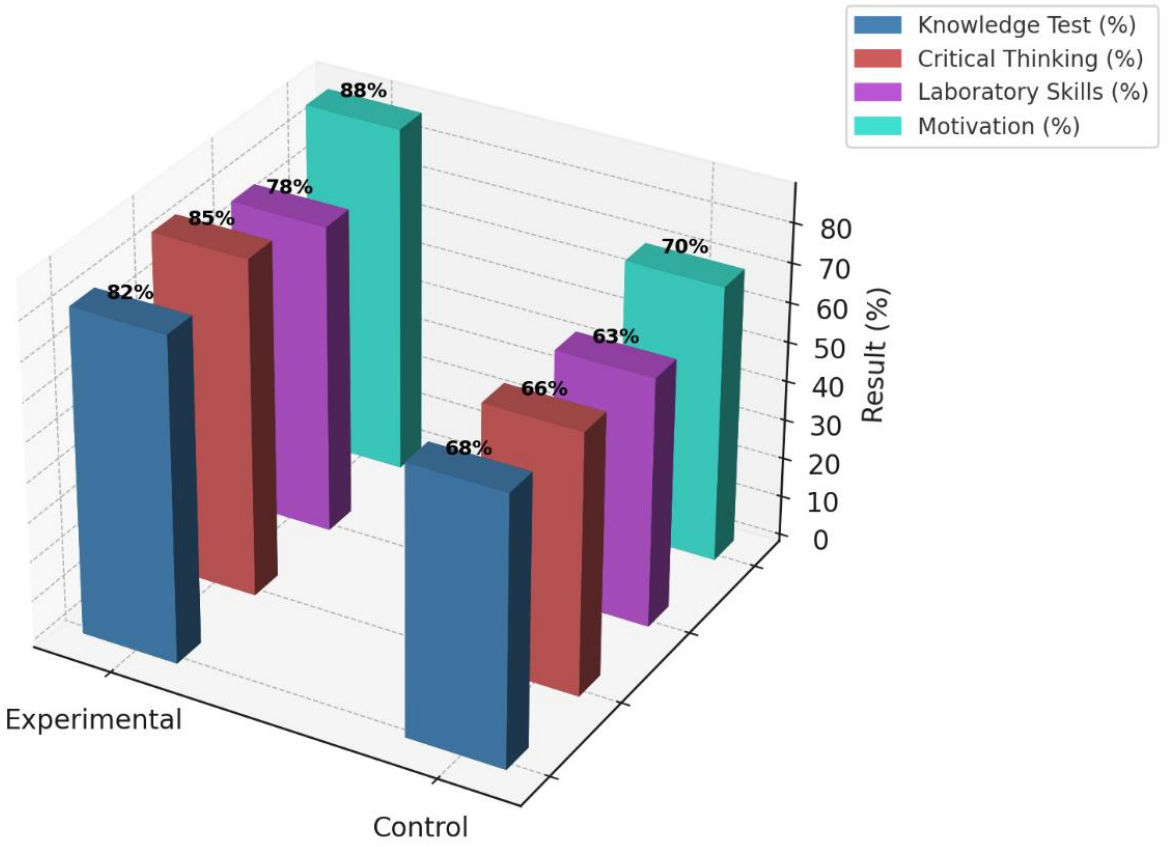
- pre- and post-tests (to measure knowledge, critical thinking, and laboratory skills),
- surveys on motivation and satisfaction,
- and observation charts specifically developed for the study.

The results of the experimental research revealed that the implementation of problem-based learning technologies led to significant improvements not only in students' knowledge levels but also in their critical thinking, independent decision-making, ability to find effective solutions in problem situations, collaboration, and participation in group activities.

The table below presents the main assessment criteria and the outcomes of the experimental and control groups.

Table 1. Assessment Results of the Experimental and Control Groups

№	Assessment Criterion	Experimental Group (%)	Control Group (%)
1	Knowledge Test	82	68
2	Critical Thinking	85	65
3	Laboratory Skills	78	62
4	Motivation (Survey)	88	70



The following diagram visually compares the results of the experimental and control groups. The diagram shows that the experimental group achieved significantly higher outcomes than the control group across all criteria. The differences were particularly pronounced in the areas of critical thinking and motivation.

During the course of the study, special methodological guides were developed for teachers, which include:

- problem-based lesson scenarios and sample tasks,
- methodological recommendations based on the stages of problem-based learning (PBL),
- guidelines for identifying and addressing potential challenges arising during lessons,
- instructions for effectively organizing group work.

In addition, lesson plans developed for topics such as Mechanical Vibrations and Waves, Thermal Phenomena, and Laws of Electric Current were piloted during the experiment. These materials were evaluated based on feedback from students and teachers and were shown to be effective in practice.

The assessment tools designed to support an effective monitoring system (pre- and post-tests, mini-tasks, surveys, observation charts) were tested in practice and evaluated as scientifically grounded.

This study reveals the potential for systematically introducing problem-based learning technologies into the teaching of physics in general education schools. At the conclusion of the study, the methodological guides, lesson plans, and monitoring tools developed for teachers are proposed as practical recommendations. Being developed and tested through experimentation, they possess scientific validity and are considered of significant importance for improving teaching effectiveness in general education schools.

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