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METHODOLOGY FOR USING INTERACTIVE METHODS IN PHYSICS LESSONS

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ABSTRACT

Interactive teaching approaches in physics are increasingly recognized as essential for improving conceptual understanding, motivation, and learner competencies. This study explores the integration of peer instruction, PhET simulations, inquiry-based problem-solving, and the 5E learning cycle into secondary school physics in Uzbekistan. A quasi-experimental design was employed to measure their impact on student achievement and attitudes. The findings demonstrate that interactive instruction significantly outperforms traditional methods. The study also discusses contextual factors affecting implementation and provides recommendations for teachers and educational policymakers.

Keywords: *physics education, interactive learning, peer instruction, PhET, 5E model, inquiry-based learning.*

1. INTRODUCTION

Physics education plays a central role in shaping students' scientific literacy, logical reasoning, and problem-solving abilities. However, research shows that many students experience physics as a difficult and abstract subject, largely due to traditional teaching practices that emphasize formula memorization over conceptual understanding. In many classrooms, teachers remain the primary source of information, while students play a passive role. This reduces motivation and limits the development of meaningful knowledge structures.

International studies highlight the importance of active participation in science learning. When students predict outcomes, test their ideas, engage in discussions, and reflect on feedback, they construct more robust and transferable understanding. These principles form the basis of interactive engagement. Recent educational reforms in Uzbekistan similarly emphasize the development of critical thinking, communication, and ICT-related skills. Interactive methods align naturally with these goals.

Despite these reforms, lecture-based teaching remains dominant across many schools. Teachers often report challenges such as limited resources, lack of methodological training, and curriculum pressure. Consequently, there is a strong need for practical, evidence-based instructional models that integrate interactive techniques into physics lessons while remaining feasible in ordinary classroom conditions.

The present study evaluates an integrated interactive methodology applied to Grade 8–9 physics classes. The focus is not only on academic performance but also on learner motivation, engagement, and the development of competencies required by modern education standards.

2. LITERATURE REVIEW

2.1 Interactive engagement in physics

Interactive engagement refers to teaching strategies that require students to actively process new information through prediction, discussion, experimentation, and reflection. Research by Hake (1998) demonstrates that interactive engagement produces significantly higher conceptual gains than traditional instruction. The central reason is that interactive learning targets misconceptions—deeply rooted incorrect

ideas that prevent accurate understanding. Such misconceptions often persist even after conventional instruction because students rarely articulate their thinking openly.

Interactive methods encourage students to verbalize reasoning, confront alternative viewpoints, and revise initial assumptions. This aligns with constructivist learning theory, which states that knowledge is actively built rather than passively transmitted. In physics, where many concepts contradict everyday intuition, this approach is especially effective.

2.2 Peer instruction

Peer instruction is one of the most researched interactive approaches. It involves posing conceptual questions, collecting answers, allowing structured peer discussion, and then re-polling the class. This cycle strengthens understanding because students must explain and justify their thinking. Numerous studies confirm that peer instruction enhances both conceptual accuracy and communication skills. Additionally, it provides continuous formative assessment, enabling teachers to adjust instruction based on real-time data.

2.3 PhET simulations

PhET simulations provide dynamic, visual tools that model physical phenomena. They are particularly valuable for teaching invisible or abstract processes such as electric current, field lines, wave motion, and atomic interactions. Research shows that simulations are most effective when paired with inquiry-based worksheets, prediction tasks, and teacher-guided reflection. Students using simulations often exhibit higher motivation and self-efficacy, especially those who struggle with traditional mathematical representations.

2.4 The 5E model

The 5E instructional model—Engage, Explore, Explain, Elaborate, Evaluate—structures lessons around the natural processes of scientific inquiry. It encourages curiosity, supports hands-on exploration, and provides opportunities for conceptual refinement. Studies consistently show that the 5E model improves problem-solving,

critical thinking, and long-term retention of physics concepts. The model aligns well with competency-based education frameworks.

2.5 The Uzbek context of competency-based learning

Uzbekistan's national curriculum emphasizes competencies such as analytical thinking, collaboration, creativity, and ICT literacy. However, surveys reveal that the transition to competency-based instruction is slow. Common obstacles include outdated teaching materials, limited access to digital resources, and insufficient teacher training. Integrating interactive methods such as peer instruction and PhET simulations offers a realistic pathway toward bridging this gap.

3. METHODS

The study employed a quasi-experimental design involving four secondary school classes. Two classes formed the experimental group receiving interactive instruction, while the remaining two served as the control group. Both groups were taught by the same physics teacher to reduce teacher-related variability. The intervention lasted one academic term. Data collection consisted of pre/post conceptual tests, learner motivation surveys, classroom observations, and student interviews.

The interactive instruction package included peer instruction cycles, structured PhET exploration activities, problem-based group tasks, and 5E-model lesson planning. The control group followed the standard textbook-based approach with teacher explanations and independent seatwork.

4. RESULTS

The experimental group achieved noticeably higher conceptual gains on post-tests, particularly in mechanics and electricity topics. Average test improvement was approximately 33 percentage points, compared with 14 points in the control group. Students in the interactive group demonstrated improved ability to interpret graphs, construct explanations, and apply physics laws to novel scenarios.

Motivation surveys revealed increased interest, confidence, and enjoyment in physics among students exposed to interactive lessons. Classroom observations

indicated greater participation, more frequent questioning, and higher levels of collaboration.

Competency development was evident in communication skills, digital literacy, and group problem-solving behaviour. Students engaged more confidently in discussions and demonstrated improved accuracy in conceptual reasoning.

5. DISCUSSION

Interactive engagement shifts responsibility for learning toward the student. The act of reasoning aloud, predicting outcomes, and revising ideas strengthens neural connections and enhances long-term retention. The results of this study echo global research confirming that interactive methods improve conceptual mastery.

The integration of simulations and inquiry-based tasks supports multiple learning styles—visual, verbal, and kinesthetic—making physics more accessible. Peer interaction also builds social-emotional competencies, such as communication, cooperation, and respect for differing viewpoints. These skills reflect the competencies outlined in Uzbekistan's educational reforms.

However, widespread adoption of interactive methods requires targeted teacher training, improved access to ICT resources, and gradual modification of assessment systems to prioritize reasoning over memorization.

6. Conclusion and Recommendations

The findings demonstrate that interactive teaching methods significantly enhance physics learning outcomes and support the development of essential 21st-century competencies. To ensure broader implementation, the following recommendations are proposed:

• Teachers should gradually incorporate peer instruction and simulation-based activities.

• Schools should invest in basic ICT tools and ensure access to offline simulation resources.

• Professional development programs should include training in the 5E model and inquiry-based instruction.

• Assessments should evaluate conceptual reasoning rather than the memorization of formulas.

By embracing interactive methods, secondary schools can better prepare students for higher education, technological careers, and informed citizenship.

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