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THE IMPORTANCE OF USING INTERACTIVE METHODS IN PHYSICS EDUCATION FOR DEVELOPING STUDENTS' KNOWLEDGE

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Abstract. This article analyses the pedagogical potential of interactive methods in physics teaching on the basis of scientific literature. Learning physics concepts solely by memorising definitions and formulas may make it difficult for students to transfer theoretical knowledge to practical situations. Therefore, the article considers the role of problem-based questions, small-group work, the "predict–observe–explain" approach, conceptual questions, and discussion of experimental results. At the same time, the effectiveness of these methods depends on lesson objectives, task quality, teacher guidance, and assessment criteria.

Keywords: physics education, interactive methods, active learning, problem-based learning, conceptual understanding, experiment, collaborative learning, pedagogical approach.

Introduction. Physics is a science based on observing natural phenomena, identifying their causes, and expressing regularities mathematically. For this reason, teaching physics should not be limited to memorising formulas. Students need to understand why an object accelerates, how heat is transferred, and which factors determine the current in an electric circuit, as well as explain their ideas using evidence. The teacher's explanations are important in achieving these outcomes, but students' independent thinking and active participation are equally significant.

In a traditional lesson, the teacher often presents information while students listen and repeat it later. Although this approach can be useful for explaining certain topics systematically, it is not always sufficient to identify students' prior ideas and misconceptions. For example, some students may believe that an object can continue moving only if a force constantly acts in the direction of its motion. It is difficult to change this idea merely by repeating Newton's laws; students need to analyse a situation, make a prediction, and discuss the outcome.

In a comprehensive meta-analysis of active learning, Freeman and colleagues reviewed 225 studies and reported that, on average, examination performance in STEM courses using active learning was higher than in courses relying on traditional lectures [1]. This does not mean that identical outcomes are guaranteed across all subjects and learning contexts. However, it demonstrates the importance of examining evidence-based methods that engage students in thinking and completing tasks.

The aim of this article is to analyse scientific literature on interactive methods used in physics lessons, consider how these methods may support students' conceptual understanding and independent thinking, and develop practical recommendations. The article addresses the following questions: What are the main pedagogical characteristics of interactive methods? How can they support the acquisition of physics concepts? How can teachers use these methods appropriately in lessons?

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Methods. The study was conducted as a descriptive literature review. Scientific articles on active learning, conceptual understanding, interactive discussion, and problem-based tasks in physics education were selected for analysis. Publications and their bibliographic information were examined using terms such as "active learning," "physics education," "conceptual understanding," "interactive engagement," and "PhET simulations." Particular attention was paid to the aims of each study, the teaching approach, the type of student activity, and the conclusions reported by the authors.

The analysis included, first, a meta-analysis comparing active learning with traditional lectures in STEM subjects [1]; second, a literature review addressing interactive simulations and active-learning environments in physics teaching [2]; and third, methodological studies focused on developing students' understanding of physics concepts. Findings were grouped by theme: active student participation, identification of misconceptions, collaborative thinking, experimentation and evidence-based reasoning, assessment, and lesson organisation. This study is not a new experimental investigation and is not presented as a comprehensive systematic review covering all available publications. The selected sources were used to illuminate the main aspects of the topic. Therefore, the conclusions should be interpreted within the scope of the literature review rather than as experimentally verified outcomes from a particular school or class.

Results. Interactive methods are teaching approaches that engage students in answering questions, exchanging ideas, solving problems, making observations, and justifying conclusions. In this process, the teacher does not merely deliver ready-made information but organises and guides learning activities. Interactivity is not defined simply by dividing students into groups or asking many questions. What matters is that students engage in meaningful thinking and support their answers with evidence. The following approaches can be used in physics lessons: posing problem-based questions; the "think–pair–share" technique; predicting an outcome before an experiment; observing and explaining experimental results; conceptual tests; solving problems in small groups; and analysing physical phenomena from everyday life. For example, the question "Which of two objects released from the same height will reach the ground first?" can encourage students to distinguish between the effects of air resistance and idealised conditions.

A physics concept has a broader meaning than a formula. A student may know the formula $F = ma$ without fully understanding the relationship between force, mass, and acceleration. It is therefore important to connect formulas with representations of phenomena, experiments, graphs, and verbal explanations. When students express the same phenomenon in several ways, their conceptual understanding can be assessed more effectively.

Conceptual questions test whether students can apply a law in a new situation rather than simply repeat a memorised definition. For example, students may be asked what happens to a cart moving on a surface with very little friction after the pushing force is removed. They can discuss their answers in pairs and then connect the situation to Newton's first law. Rather than immediately penalising an incorrect answer, the teacher can help students identify which part of their reasoning is valid and which part needs revision.

A review of literature on PhET simulations examined 31 experimental or quasi-experimental studies and concluded that such simulations may help improve students' understanding of physics concepts [2]. This indicates that interactive methods need not be limited to verbal discussion: visual and digital tools can also support active thinking when they are integrated appropriately into learning.

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The "predict–observe–explain" approach consists of three stages. First, students predict the outcome of an experiment and explain their reasoning. Second, they observe the experiment or demonstration. Third, they compare their prediction with the actual result and explain any difference. This approach helps reveal students' initial ideas and connect new knowledge with their existing understanding.

During group work, students learn to divide tasks, listen to one another, provide evidence, and reach a shared conclusion. When solving a physics problem, one student may list the given quantities, another may select the appropriate formula, a third may check the calculations, and a fourth may explain the solution. However, tasks and time limits must be clearly defined to ensure that all students participate.

A key benefit of collaboration is that students test their understanding by expressing their ideas verbally. If a student cannot explain why a particular formula was selected, this signals that the topic may need to be reviewed. The teacher can compare group responses and identify common errors. In this way, assessment becomes not only a means of checking the final answer but also a tool for guiding the learning process.

In an interactive lesson, assessment should not be limited to a test at the end. Short questions, response cards, one-minute written explanations, conceptual tests, and peer review can be used to monitor understanding during the lesson. Feedback should be specific. Instead of simply saying "incorrect," the teacher might say, "You selected the correct formula, but you need to divide the change in velocity by the time interval." Such feedback helps students understand what to do next.

Teachers can analyse students' responses and use them to plan subsequent lessons. If many students make the same mistake, this may indicate not only a difficulty on the students' part but also a need to reconsider the explanation or task. In this respect, interactive methods also serve a diagnostic function.

Discussion. The literature review suggests that the value of interactive methods lies not merely in keeping students busy, but in making their thinking visible. When students make predictions, provide evidence, or explain their solutions, teachers gain more information about their understanding. Freeman and colleagues' meta-analysis reports generally positive outcomes for active learning in STEM subjects [1]. A review focused on physics education also supports the integration of simulations into active-learning environments [2].

Nevertheless, the name of a method does not automatically guarantee its effectiveness. If group work lacks a clear purpose, some students may complete the task while others remain passive. If a problem-based question is not suited to students' level of preparation, it may create confusion rather than encourage reasoning. Teachers should therefore consider task difficulty, available time, class size, equipment, and students' prior knowledge.

In practice, a lesson can be organised into three stages. First, prior knowledge is elicited through a short question or a real-life situation. In the main stage, students work on an experiment, a problem, or a group task. At the end, they connect their findings to the scientific concept and write a brief reflection. This sequence helps maintain a clear focus on the lesson objectives. The teacher can provide the necessary theoretical explanation at each stage.

Conclusion. The scientific sources reviewed suggest that the purposeful use of interactive methods in physics lessons can support students' active engagement, evidence-based reasoning, and meaningful understanding of physical laws. Problem-based questions, the "predict–observe–explain"

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approach, conceptual tasks, and collaborative problem-solving enable teachers to identify students' initial ideas and compare them with scientific explanations.

To use interactive methods successfully, teachers should define clear objectives, adapt tasks to students' level, involve all participants, and provide meaningful feedback. Since this article is based on a literature review, its conclusions are not the results of an experiment conducted in a local classroom. A useful next step would be to trial the recommended methods in actual lessons and evaluate the outcomes systematically.

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