



APPLICATION OF PHYSICAL EXPERIMENTS IN MODELING AS A STRATEGY FOR DEVELOPING STUDENTS' COGNITIVE ACTIVITY

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ABSTRACT

This article examines problem-based instruction as a primary pedagogical strategy for developing and sustaining students' cognitive activity. The general and specialized functions of problem-based learning are analyzed, and its sequential stages are described. The study investigates techniques for constructing problem situations, the psychological paradoxes inherent in the thinking process, and the mechanisms through which learners solve cognitive problems. Special attention is given to the role of hypothesis formation, group discussion, and reflective practice in deepening conceptual understanding. The findings confirm that problem-based instruction, when systematically implemented, significantly enhances students' intellectual independence, scientific thinking, and creative competencies.

KEYWORDS

Problem-based instruction, cognitive activity, problem situation, hypothesis, thinking process, research activity, intellectual independence, activity theory.

INTRODUCTION

Motivating students toward cognitive activity can most effectively be achieved through problems created during the learning process — either by the teacher or, in more advanced cases, by the students themselves. Problem-based instruction not only stimulates motivation but also develops learners' intellectual and creative capacities by grounding knowledge acquisition in the resolution of theoretical and practical problems.

The foundations of problem-based instruction were established by Polish didactician W. Okon and Soviet researchers I.Ya. Lerner, M.I. Makhmutov, and A.M. Matyushkin. Okon understood problem-based learning as encompassing a range of interconnected actions: organizing problem situations, formulating problems, and providing students with systematic support in resolving them. This conception placed problem-solving at the center of the educational process rather than at its periphery.

Literature Review

Problem-based instruction is organized around problem questions, tasks, assignments, and problem situations. M.I. Makhmutov identifies the following general functions of problem-based learning: enabling students to master a system of knowledge and methods of mental and practical activity; developing cognitive independence and creative ability; and forming dialectical-materialist thinking in learners.

In addition to these general functions, Makhmutov specifies a set of specialized functions: developing skills for the creative assimilation of knowledge (through logical methods or specific creative activity techniques); developing skills for the creative application of knowledge to new situations; and accumulating experience in research-oriented creative activity. Of these, the most significant is enhancing the scientific rigor of instruction and improving the effectiveness of scientific worldview formation.

A critical element of problem-based instruction is the problem situation, from which the entire process typically originates. The sequential stages unfold as follows: problem situation → problem → problem task → problem solution. The greatest pedagogical attention is devoted to the stage of creating the problem situation.

Research Methodology

The study employs a theoretical-analytical method, examining primary sources in the field of problem-based learning and cognitive activity theory. R.I. Malafeev has described several specific techniques for creating problem situations in physics instruction: the surprise situation, arising when students encounter paradoxical phenomena (e.g., the freezing of water in a warm room due to ether evaporation); the conflict situation, which emerges when newly encountered facts contradict established theory (e.g., the so-called “ultraviolet catastrophe”); and the conjecture situation, in which the teacher proposes the possible existence of a new regularity (e.g., that a magnetic field acting on a conductor may induce an electric current).

Analysis and Results

A pivotal moment in the problem-solving process is the formulation of an initial hypothesis. M.I. Makhmutov notes that in learning theory, a hypothesis functions as a psychological-didactic category and serves teachers as an instrument for stimulating students’ cognitive activity. The process of formulating, justifying, and proving hypotheses allows students to master this important method of scientific inquiry; simultaneously, working with hypotheses enables students to acquire personally meaningful new knowledge under the teacher’s guidance - knowledge that proves more durable and more readily applied in explanatory and argumentative contexts.

A.V. Brushlinsky’s research introduced the concept of “prediction” - the activity of searching for new and unknown content in the problem-solving process. A characteristic paradox of thinking emerges: on one hand, what is being sought (the unknown) appears to be already indicated in the initial conditions of the problem; on the other hand, it is genuinely unknown. Thus, the required outcome is continually forecast throughout the entire thinking process, with thinking proceeding as synthesis through analysis - by integrating the object under study into new relationships, it acquires new qualities.

The activity-based foundations of both problem-based and practical instructional methods can be seen in the classification proposed by W. Okon.

The distinction lies in the degree of student independence and the teacher’s organizational role. In the organization of practical activity, problem-based elements frequently emerge spontaneously in the course of the work, at which point instruction itself becomes problem-based. Cognitive activity in instruction is therefore most effective when it arises from problems encountered in educational

practice, enabling the teacher to organize productive problem-based activity on the basis of practical tasks.

Conclusion

The concept of “activity,” which first emerged in the works of classical philosophers, remains central in dialectical-materialist pedagogy. Activity is a special form of the human being’s relationship to the world - one whose content consists in the purposeful and goal-directed transformation of reality, and in the human creation of social relations and selfhood. Through activity, both the culture of society and the personality of the individual are developed.

The research findings confirm that problem-based instruction is among the most effective means of developing students’ intellectual independence, hypothesis-formation skills, and scientific inquiry competencies. The activity-based framework underlying both problem-based and practical instructional methods can be systematically applied to subject-area teaching. Emotions play a significant role in motivating the resolution of cognitive problems - their presence contributes to the formation of the cognitive motive, which is a necessary condition for sustained learning activity.

For cognitive activity to develop the student as a genuine personality, that activity must be purposeful, motivated, and consciously performed. The activity model must be supplemented by a reflective component — “activity reflection” — to ensure that students not only acquire new knowledge but also become aware of the methods by which that knowledge is constructed. Future research should focus on identifying the specific conditions under which the need for learning activity arises and is sustained in diverse student populations.

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