

METHODOLOGY FOR DEVELOPING STUDENTS' INNOVATIVE THINKING COMPETENCE BASED ON THE STEAM APPROACH

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Abstract: This article examines the pedagogical and methodological possibilities of developing students' innovative thinking competence through the STEAM approach in general secondary education. The interdisciplinary nature of STEAM education, students' ability to analyze problem situations, generate new ideas, test them through practical activities, and improve the obtained results are discussed from a scientific perspective. Particular attention is also paid to the role of project-based activities, problem-based learning, design thinking, experimentation, modeling, collaborative learning, and reflective assessment in the formation of innovative thinking competence. The article further highlights the pedagogical functions of the teacher, the stages of students' learning activities, and the criteria for assessing innovative thinking in the organization of STEAM-based lessons.

Keywords: STEAM education, innovative thinking, competence, interdisciplinary integration, creative activity, problem-based learning, project method, design thinking, modeling, reflection

In the modern education system, one of the priority pedagogical tasks is to develop students not merely as recipients of ready-made knowledge, but as active individuals capable of applying existing knowledge in new situations, independently analyzing problems, developing non-standard solutions, and transforming their ideas into practical outcomes. The technological development of society, the rapid growth of information flows, and the increasing complexity of professional activities create a need to develop productive, creative, and innovative thinking rather than reproductive thinking among students. In this process, the STEAM approach serves as an effective pedagogical mechanism that makes it possible to connect students' theoretical knowledge with practical activities by organizing educational content on the basis of interdisciplinary integration. The concept of STEAM represents the integration of Science, Technology, Engineering, Art, and Mathematics. The main methodological feature of this approach is the integrated application of knowledge acquired in different subject areas when solving a specific problem, project, or practical task, rather than treating such knowledge as isolated components. This enables students to consider a single issue from different perspectives, identify relationships among different areas of knowledge, and generate alternative solutions. As a result, the educational process places greater emphasis not on merely memorizing knowledge but on reorganizing, transforming, and applying it in new contexts.

Innovative thinking competence includes a student's ability to identify a problem, critically analyze an existing situation, propose several alternative ideas, select the most appropriate option among them, test the proposed solution in practice, and improve it on the basis of the results obtained. This competence is not limited solely to creativity. Innovative thinking requires not only the generation of new ideas but also the justification of their practical value, the rational use of available resources, the evaluation of outcomes, and, when necessary, the redesign of the proposed solution. Therefore, in STEAM education, it is advisable to organize students' thinking activities according to the sequence of “problem - idea - project - experiment - result - improvement.” In

STEAM-based lessons, the teacher gradually moves away from being the primary source of ready-made answers and assumes the role of a facilitator who designs, directs, and supports the pedagogical process. The student, in turn, becomes an active participant who independently investigates problems, searches for information, analyzes data, conducts experiments, and evaluates the results of his or her own activities. For example, when students are given the task of designing an environmentally friendly school environment, they may study biological factors, mathematically calculate the dimensions of the area, determine technological possibilities, develop an engineering structure, and create the aesthetic appearance of the project. During such activities, the integrative nature of knowledge acquired from different subjects becomes evident, while students gain experience in addressing real-world problems in a comprehensive manner.

Problem-based learning plays a particularly important role in the methodology of developing innovative thinking. A problem situation creates an intellectual contradiction between the student's previous knowledge and a new task. This contradiction creates an internal need to search for new knowledge and solutions. In this context, the teacher should stimulate students' divergent thinking through open-ended questions such as: “How can this problem be solved differently?”, “What solution would you propose if the available resources were limited?”, and “Which aspects of the proposed model could be improved?” Unlike closed-ended tasks that require a single correct answer, such activities allow for several reasoned solutions and encourage students to explore different possibilities.

The project method is another important tool for developing innovative competence within the STEAM approach. During project activities, students identify a problem, determine goals and objectives, collect information, develop possible solutions, create a model or prototype, test the results, and draw conclusions. This process does not limit students to the acquisition of theoretical knowledge but also develops their abilities to plan, distribute responsibilities, communicate, make decisions, and present outcomes. In collaborative projects, in particular, students gain experience in discussing different ideas, accepting or rejecting others' opinions on the basis of evidence, and reaching common decisions. This strengthens the social and communicative dimensions of innovative activity.

The use of design thinking technology is also effective in STEAM education. Design thinking encourages students to understand users' needs, clarify problems, generate various ideas, create prototypes, and test them. An important feature of this process is that mistakes are regarded not as negative outcomes but as valuable sources of information for further improvement. In traditional education, students may often be afraid of making mistakes. In a STEAM environment, however, even an unsuccessful experiment may provide important conclusions for the next stage of learning. Therefore, teachers should assess not only the final product created by students but also the reasoning process, experimentation, modifications, and decisions that led to that result. The inclusion of the Art component within STEAM has particular pedagogical significance in developing students' innovative thinking competence. Art activates students' aesthetic perception, imaginative thinking, creativity, and emotional engagement, while adding humanistic and aesthetic value to technical and scientific solutions. A product that is well-designed from an engineering perspective must be not only functional but also convenient, understandable, and aesthetically attractive. Therefore, the “Art” component in STEAM should not be regarded as a decorative addition but rather as an essential component of creating an innovative product.

In the effective organization of STEAM lessons, the assessment system should also differ from traditional approaches. Assessment should focus not only on the student's final answer or completed product but also on their understanding of the problem, the number and originality of

ideas, ability to provide justification, integration of knowledge, experimentation, improvement of the model, and reflective thinking. Accordingly, criteria for assessing innovative thinking may include the level of problem identification, flexibility of ideas, originality of proposed solutions, application of scientific and technological knowledge, development of practical outcomes, and the ability to reflect on one’s own activities. Such an assessment approach contributes to the formation of motivation to learn not merely for results, but for personal and intellectual development. The effectiveness of a methodology aimed at developing innovative thinking through STEAM also depends directly on the extent to which lesson content is connected with real-life problems. If students are given an abstract project unrelated to their everyday lives, their intrinsic motivation may decrease. In contrast, tasks related to energy conservation, efficient use of water resources, improvement of school environments, development of environmentally friendly products, creation of devices for people with disabilities, and design of smart classroom models encourage students to think about socially significant problems. Through such projects, students become aware of the practical value of their knowledge and understand that an innovative idea should be aimed at satisfying a specific social need.

Developing students’ innovative thinking competence through the STEAM approach requires the reorganization of the educational process on the basis of interdisciplinary integration, creative inquiry, experimentation, project design, and reflective activity. This approach directs students away from the passive reception of ready-made knowledge toward the independent creation of new knowledge and solutions. The systematic application of problem-based learning, project activities, design thinking, modeling, and collaborative learning develops students’ abilities to identify problems, generate alternative ideas, apply interdisciplinary knowledge, test their solutions in practice, and improve them. Therefore, STEAM education should be regarded not simply as an individual method for developing innovative thinking, but as an integrated pedagogical system aimed at preparing students for a complex and rapidly changing social and technological environment.

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