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The role of integrating theoretical and practical knowledge in STEAM science education

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Abstract. This article examines the role of integrating theoretical and practical knowledge in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education, with a particular focus on modeling as an essential tool in the learning process. It highlights the significance of physical and mathematical modeling in developing students' research skills, abstract thinking, and creative abilities. The study emphasizes that modeling, as a simplified and idealized representation of real-world objects, serves epistemological, illustrative, heuristic, and integrative functions. Special attention is given to the organization of problem-solving processes, where heuristic approaches and research-based learning enhance students' ability to analyze, generalize, and formulate hypotheses. The paper also discusses the importance of aligning educational content with professional requirements in technical higher education institutions, ensuring that students acquire relevant competencies for their future careers. Ultimately, the integration of theoretical knowledge with practical application in STEAM disciplines fosters multidisciplinary thinking, creativity, and professional readiness among students.

Keywords. STEAM education, modeling, theoretical and practical integration, mathematical modeling, scientific research, heuristic methods, technical thinking, abstract thinking, problem-solving, interdisciplinary learning, engineering education, professional competence.

Introduction

In the 21st century, education systems are increasingly shifting toward integrated approaches that connect theoretical knowledge with practical application, particularly within STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. This integration is essential because modern economies demand not only subject-specific knowledge but also the ability to apply concepts

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in real-world contexts. According to the World Economic Forum (2023), skills such as problem-solving, critical thinking, creativity, and collaboration are among the most востребованные competencies, all of which are effectively developed through practice-oriented learning.

Research shows that students retain up to 75% of knowledge when they actively engage in hands-on activities, compared to significantly lower retention rates through passive learning methods such as lectures. This highlights the importance of combining theoretical instruction with experiential learning in STEAM education. For instance, engineering design projects, laboratory experiments, and interdisciplinary problem-solving tasks allow learners to test abstract concepts, thereby deepening their understanding and improving long-term retention.

Furthermore, integrating theory and practice supports the development of transferable skills. A report by UNESCO emphasizes that experiential and project-based learning environments enhance learners' ability to adapt knowledge across different domains. In STEAM education, this is particularly important, as real-world problems—such as climate change, sustainable development, and technological innovation—require interdisciplinary solutions that go beyond isolated theoretical understanding.

In addition, the inclusion of the "Arts" component in STEAM fosters creativity and innovation, bridging the gap between analytical thinking and imaginative problem-solving. Studies indicate that students exposed to integrated STEAM curricula demonstrate higher engagement levels and improved academic performance compared to those in traditional, discipline-separated systems.

Therefore, the integration of theoretical and practical knowledge in STEAM education is not merely a pedagogical preference but a necessity for preparing students to meet the complex challenges of the modern world. This article explores how such integration enhances learning outcomes, promotes innovation, and contributes to the development of a highly skilled and adaptable workforce.

The model never reflects all the properties and specific aspects of the object under consideration, it is not identical to it. It is based on simplification, idealization, and is an approximate reflection of the object.

Modeling has the following functions:

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epistemological - simplified study of objects in science, their direct study is not possible for one reason or another;
illustrative - creating a basic intuition for analysis and generalization;
heuristic - obtaining new knowledge;
integrative or synthesizing - establishing a single model of knowledge [6].
An important part of the organization of scientific research work on creating physical or mathematical models of students is the study of the problem of the object associated with the elements of research [6]. Research of this type does not require any extra time from students and the teacher and is an integral part of the educational process, covering all students as an equally interesting activity. Here we will look at solutions to problems of varying degrees of complexity, requiring non-standard approaches, and making them an object of research that models STEAM disciplines.
As a result of conducting STEAM modeling research, each student develops the ability to distinguish between important and unimportant aspects of a given object or phenomenon, to combine the research sequence, to systematize, to formulate hypotheses, and other similar skills. In general, in the process of searching for solutions to such problems, intensive development of thinking skills continues, and as a result, abstract thinking is formed in students.
In order for students to organize the process of modeling STEAM research, it is not enough to choose a good problem, but it is necessary to properly organize the process of solving it. First of all, it is necessary to distinguish the sequence of stages of solving the problem from the pedagogical point of view. In most cases, traditional practice begins with work on specific solutions to the problem and ends with this, and the most important stages for the development of creative activity - understanding the problem, searching for its solution and generalizing it - are not implemented. In such a methodology, the goal is only to find a solution to the problem, and students are not taught the methods of searching for and researching the solution.
Work on the problem should, first of all, be aimed at forming general methods for searching for a solution. The constant use of a system of heuristic instructions will help to successfully search for a solution. Therefore, in STEAM subject education, scientific and research work on creating physical or mathematical

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models by integrating theoretical and practical knowledge by students is aimed at achieving the following goals:
- improving the preparation of highly qualified, creatively thinking students for professional activity, as a multidisciplinary education, helping to develop students' creative abilities and personality.
In general, an analysis of the curricula of technical higher educational institutions shows that STEAM subjects are present in all educational areas, and This, in turn, means that STEAM education can be introduced in higher education. In the implementation of STEAM education, the study of subjects should be complementary and integrate interrelationships according to the content and logic of the topics of the subject programs. In this regard, it is important to note that the topics in the student load allocated for independent study of the subject should simultaneously form the student's knowledge, skills and abilities in the subject, and be based on the connection between the fundamental disciplines of the specialty. One of the important aspects of the educational process is that students of technical higher education institutions have their own unique thinking.
As is known, a three-component structure of technical thinking has been identified: conceptual-figurative-practical [1]. For students of technical disciplines, the use of images is important in studying exact sciences. It is necessary for engineers to have the skills to work with information in the form of diagrams, drawings, tables in technical documents. The process of modeling various phenomena is also associated with the application of figurative structures. Therefore, the use of images (drawings, diagrams, tables, etc.) is one of the important organizers in imparting mathematical knowledge to future engineers. Also, an important characteristic of the engineer's worldview is the ability to systematically study, analyze, classify and study the specific aspects of a phenomenon. Only if the goals are presented to students in a generalized, understandable language can results be achieved in education.
One of the important aspects of a modern engineer is the ability to implement a creative approach to professional activity, having independent thinking. Without a creative approach, neither a single discovery, nor the further development of technical sciences that form the basis of the specialty, nor the growth of the

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professional skills of an engineer are possible. Thus, education in the exact sciences
It is necessary to develop abstract-logical, intuitive spatial-figurative and creative thinking in students during the process.
The analysis of the course of exact sciences studied in higher education in the chosen specialty should include an assessment of educational programs and a description of the content of the mathematics course according to the following criteria, taking into account:
-the purpose of exact sciences education for this specialty;
-analyses of the application of knowledge from exact sciences in general and specialized subjects;
-application of topics and concepts of professional nature;
-correspondence of problem-solving methods necessary for a future specialist to methods in exact sciences (analytical, approximate);
-application of the professionally important method of mathematical modeling at the main stages [2];
-correspondence of mastering various topics to the allotted time.
Many researchers [3, 4, 5,6] in their research have studied the problem of vocational orientation in a general way for a technical higher educational institution, without considering specialties separately, but bringing the studied topics into a single system with the content of general professional directions. The analysis shows that although the specialized disciplines of different technical specialties often rely on the material of different exact sciences and use different mathematical apparatus to solve professional problems, the same approach is taken for them. For example, in construction mechanics - vector and linear algebra, differential equations, in automation, in information technologies - complex analysis, differential equations, random events, etc.
In general professional subjects: theoretical mechanics, resistance of materials, hydraulics, machine details, electrical engineering and electronics, metrology, etc., as noted, are studied in different specialties in different volumes in terms of their essence and content, based on the State Educational Standards. The requirements for knowledge of exact sciences for these subjects are correspondingly different. Thus, when presenting knowledge obtained from

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STEAM subjects, it is necessary to have an idea of what the student will need in his further activities, which material to pay more attention to teaching, and for this the teacher will need to study the area of application of mathematical knowledge for students of each specialty. Conducting the above analysis for general professional and specialized subjects, which are part of STEAM subjects, requires paying attention to the following:
- which areas of exact and natural sciences are used most often (specific concepts, topics, sections);
- what methods are used (mathematical apparatus).

In the process of teaching mathematics in technical universities, it is necessary to be able to distinguish specific areas in order to apply concepts related to specialization, especially in professional matters.

Conclusion

In conclusion, the integration of theoretical and practical knowledge in STEAM education plays a crucial role in preparing students for professional and research-oriented activities. Modeling serves as an effective pedagogical tool that enhances students' ability to think abstractly, analyze complex phenomena, and apply knowledge in real-world contexts. The proper organization of the problem-solving process, including understanding, exploration, and generalization, is essential for developing creative and independent thinking. Furthermore, aligning STEAM subjects with the specific requirements of technical specialties ensures that students acquire relevant knowledge and skills for their future professions. Therefore, the implementation of interdisciplinary and research-based approaches in education contributes significantly to the development of highly qualified, innovative, and competent specialists.

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