Improving The Methodology For Developing Future Engineers' Competencies In Computer Modeling

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ABSTRACT

The article examines the theoretical and methodological foundations for improving the process of developing computer modeling competencies among future engineers in the context of digital education. It analyzes the pedagogical conditions, structural components, and stages of competency formation through an integrative approach combining technical disciplines, digital tools, design thinking, Computer-supported collaborative learning**,** project-based learning. The research emphasizes the importance of interactive modeling environments, simulation technologies, and interdisciplinary integration in enhancing students' analytical, creative, and problem-solving skills. The proposed methodology aims to strengthen engineering education by linking theoretical knowledge with practical modeling experience, ultimately fostering innovation-oriented specialists.

Keywords: computer modeling, engineering education, digital technologies, competencies, integration of disciplines, design thinking, collaborative learning, project-based learning, methodological improvement,

In the context of rapid technological progress and digital transformation, the education system faces new challenges related to the preparation of specialists capable of working effectively in an increasingly automated and data-driven industrial environment. One of the core competencies of the modern engineer is the ability to apply **computer modeling** methods for designing, analyzing, and optimizing complex technical systems. As Industry 4.0 and digital engineering technologies become integral to production, the development of computer modeling competencies is not only a professional requirement but also a key factor determining the competitiveness and innovative capacity of future engineers.

However, despite the growing importance of modeling in engineering practice, the existing educational methodologies often remain fragmented, with insufficient integration between theoretical disciplines, programming tools, and practical applications. Many university programs emphasize theoretical instruction over applied learning, which limits students' ability to translate abstract knowledge into digital design and modeling solutions. Consequently, there is a pressing need to develop a comprehensive **methodological framework** that ensures the systematic formation and improvement of computer modeling competencies in engineering education.

The improvement of methodology in this area requires an **interdisciplinary and integrative approach**, combining knowledge from mathematics, physics, computer science, and engineering technology. This approach must also be supported by modern digital tools — including simulation software, virtual

laboratories, and project-based learning environments — that allow students to engage in real-world modeling tasks and problem-solving scenarios. Moreover, the integration of **interactive learning platforms** and **collaborative modeling projects** enhances not only technical proficiency but also teamwork, communication, and critical thinking skills, which are crucial for professional success in the digital economy.

The concept of **competence-based education** plays a central role in improving computer modeling methodology. Within this paradigm, learning outcomes are defined not merely as the acquisition of knowledge but as the ability to apply knowledge effectively in professional contexts. Therefore, developing modeling competencies should focus on building practical experience, creative thinking, and analytical decision-making abilities. A systematic combination of **project-based**, **problem-oriented**, and **simulation-based learning methods** can provide a strong foundation for this process.

The purpose of this research is to develop and justify a methodology for improving future engineers' computer modeling competencies through the integration of disciplines in the digital learning environment. This methodology aims to align educational processes with the modern demands of engineering practice and to support the formation of digital literacy, design thinking, and technological adaptability among students. The study explores theoretical foundations, pedagogical conditions, and practical tools necessary for building an effective model of competency development in engineering education.

Ultimately, the proposed methodological framework contributes to the modernization of engineering education, ensuring that graduates are equipped with the skills and knowledge required to participate in innovative production processes and to adapt to emerging technologies. Through the integration of digital tools, interdisciplinary collaboration, and competency-based teaching, engineering programs can better prepare students to become the next generation of technologically competent, creative, and solution-oriented professionals.

One of the didactic tasks of an educational institution is to form the thinking and intellect of students, and an important component of the implementation of such didactic tasks is to develop.

In the practice of automating design processes, the development of computer modeling competencies of students of technical specialties is of great importance. In this case, the skills and qualifications of students of technical specialties to understand the essence of a given design problem and to create a project are formed.

Today, special attention is paid to this issue in the continuing education system, and in higher educational institutions, it is necessary to teach students of technical specialties to algorithmize various engineering problems. However, the results of our observations have shown that most students find it difficult to create a project for a given engineering problem and translate it into the code of any programming language. As a result, this leads to a decrease in students' interest in design and the failure to form and develop computer modeling competencies.

One of the main reasons for the emergence of these problems is that in the system of continuing education, technical specialties do not pay attention to logical consistency when teaching students to create projects, and most of the tasks given are aimed at modeling engineering problems. In our opinion, in order to increase students' interest in software development and develop their competence, it is necessary to first thoroughly teach the design of engineering problems. In this case, the engineering problems given should be linked to life and technical processes. On this basis, it is possible to increase students' interest in designing and improve their skills and qualifications in creating complex projects.

Therefore, within the framework of the study, special attention is paid to this issue and we recommend that when teaching students to design in higher education institutions, the following categories of problems be given to students. During the study, we were convinced that teaching students to design problems in

two different forms, that is, in the form of a block diagram and a program, is effective. The following problems can be cited as examples of these.

Students' independent work is assessed at the following levels: unsatisfactory-reproductive, satisfactory-variative, good-partially research, excellent-creative.

At the unsatisfactory-reproductive level, students simply provide answers to the questions asked by electronic literature on independent work without analyzing the sources. They may not be able to write their own opinions, conclusions and suggestions on the topic of independent work. Along with the shortcomings noted, they cannot solve the problem situations in the web quest on the topic.

At the satisfactory-variable level, students cannot provide answers to the questions asked by electronic literature for independent work, partially analyzing the sources. They can express their own opinions, comments, and their own conclusions and suggestions on the topic of independent work. They do not have the opportunity to solve the problem situations in the web quest given on the topic.

At the good-partially searchable level, students analyze the information obtained from the sources of electronic literature for independent work, and present their answers to each question creatively. They write their own opinions, conclusions, and suggestions on the topic of independent work. They complete the problem situations in the web quest given on the topic, encounter problems in applying them in practice.

At the highly creative level, students analyze and summarize the information obtained from other sources in the electronic literature for independent work, and present their answers to each question scientifically. They should write and explain their opinions, conclusions, suggestions and recommendations on the topic of independent work. In conclusion, we recommend that future engineers use the algorithm developed within the framework of the research, the recommended issues and the electronic platform environment to develop their computer modeling competencies. As a result, students' computer modeling competencies will develop.

The following interactive teaching methods were used in our research:

The main goal of the design thinking method is to understand the needs of users and find the best solutions for them.

The main stages of the design thinking method:

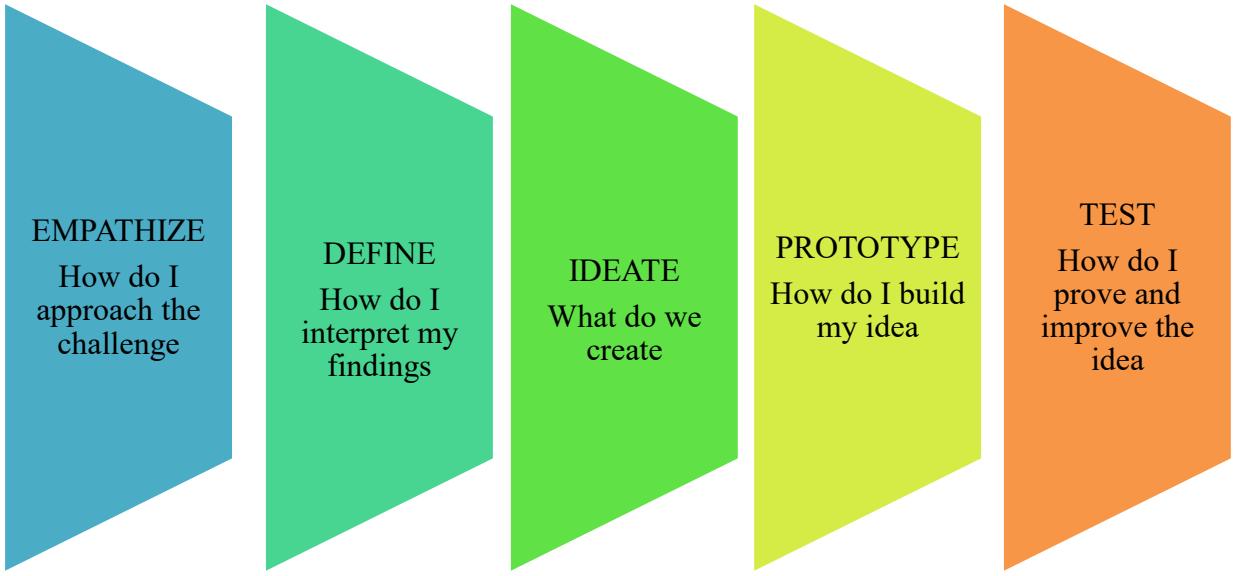

Figure 1. The process of applying the Design Thinking method.

1. Empathize: Study the world of users to understand their needs and problems and try to understand their situation.
2. Define: Define the users' problems clearly based on the information obtained.
3. Ideate: Develop different approaches and ideas to solve the problems.
4. Prototype: Create prototypes to implement the ideas and test them.

5. Test: Test the prototype on users and analyze the results.

Advantages of the design thinking method:

Focus on user needs, Finding innovative solutions, Effective problem solving, Feedback-based approach.

Project-based learning (PBL) is a teaching method that encourages learning through active participation in real-life and personally meaningful projects.

Students usually work on projects for a long time, from a week to a semester, which involves them in solving a real problem or answering a complex question. Project-based learning is a learning method in which students learn by solving complex questions, problems, or challenges. It encourages active learning, engages students, and allows for higher-level thinking. Students are tasked with exploring and finding answers to real-life problems by completing their own projects. Students also have control over the project they are working on, in particular, how the project is completed, and the final product.

In today's era of widespread digital technologies, one of the main tasks of engineering education is to develop solid and practical competencies in computer modeling in students. The use of the Project-Based Learning (PBL) method is a particularly relevant and effective approach to achieving this goal. This method brings the topics being studied closer to real life, develops students' skills in deep thinking, independent research, and professional problem-solving.

Project-based learning is an activity in which students work long-term and step-by-step on solving a problem they have chosen or are given, and ultimately create a specific practical product (model, graph, software module, etc.). This approach is a natural fit for teaching computer modeling. Because modeling itself is a process of analyzing a real system, mathematically expressing it, describing it in a computer environment, analyzing it, and interpreting the results.

The main effect of the PBL method is that it forms in students the qualities of an active, independent, critical thinker and creative specialist. The student learns not only theoretical knowledge, but also how to apply it, which tool to use where, and how to present the result. For example, during the project, students perform real tasks such as creating models of mechanical parts in SolidWorks, simulating physical processes in MATLAB, or building a 3D model based on a drawing in AutoCAD.

During the project work, students work in groups, assign roles, manage time and resources, and find solutions together when problems arise. This develops not only their technical competence, but also transversal skills such as cooperation, responsibility, and communication. In this way, during the project, the student is ready to work on himself, grow professionally, and evaluate the result.

It should be noted that with the help of the Project-Based Learning method, students' motivation is much higher, because they see the result of their work, create models based on their ideas and exchange ideas. The final product becomes the main criterion for assessment: this makes the assessment process transparent, fair and effective.

The project-based learning method is one of the most effective approaches to developing computer modeling competence. Through this method, the student becomes not just a possessor of knowledge, but also a creative specialist who can make the right decisions in problem situations, create and present his own project. As a result, an important step is taken towards training competitive engineering personnel based on innovative approaches in higher education.

The formation of computer modeling competence is becoming an increasingly relevant issue in modern engineering education. This competence includes the skills to accurately, analytically and systematically represent, evaluate and improve engineering processes in a digital environment. In order to effectively develop these skills, along with traditional methods, innovative approaches, in particular, the Computer-Supported Collaborative Learning method, are of great importance.

The CSCL method is based on students' learning through mutual communication, exchange of knowledge and experience, and joint problem-

solving activities. In this case, computer technologies serve as a mediating tool: group project environments, cloud platforms, online modeling programs, and virtual educational resources make this process convenient and effective.

The use of this method, first of all, helps to deepen the knowledge of modeling. Students, by analyzing the problem not independently, but together, discuss different approaches, look for alternative solutions, and develop the optimal option. This process strengthens their analytical thinking, critical thinking, and decision-making capacity.

In addition, with the help of CSCL, students develop the skills to use digital technologies in a targeted manner. Working in groups using programs such as SolidWorks, MATLAB, and AutoCAD allows them to practice real-world work processes. Especially in a collaborative environment, universal competencies such as task allocation, time planning, and presentation of results are also developed.

This method also increases intrinsic motivation to learn. Stages such as group work, responsibility, contribution, feedback and presentation of results form a positive attitude towards learning in students. In the assessment, a fair approach based on the role of each participant in the process, the final product and presentation encourages students to be more active.

The computer-supported collaborative learning method is an effective pedagogical tool for forming computer modeling competencies. It forms not only technical knowledge, but also professional and personal competencies, preparing students as flexible, intellectual and innovative engineers in the modern production environment.

In conclusion, it is effective to link the given issues to technical and life processes in developing students' computer modeling skills. On this basis, it is achieved to increase students' interest in automating design processes and to teach them to automatically design various complex problems. As a result, students' computer modeling competencies develop.

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