KEY FACTORS IN DEVELOPING STUDENTS' DESIGN AND CONSTRUCTION COMPETENCE

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Abstract: *This article analyzes the key qualities and principles involved in developing students' design and construction competence. Today, in the field of education, fostering knowledge and skills related to engineering and construction activities holds significant importance. The article highlights core factors such as teaching methods, digital technologies, integration with practical experience, and the development of creative thinking in the advancement of design and construction competence. Additionally, it evaluates the effectiveness of modern pedagogical technologies and innovative approaches, exploring ways to implement them into the educational process. The research findings contribute to improving the quality and effectiveness of education in engineering and technical disciplines.*

Keywords: *design and engineering competence, innovative approach, digital technologies, creative thinking, pedagogical technologies.*

Аннотация: *В данной статье анализируются основные качества и принципы развития проектно-конструкторской компетентности студентов. В современном образовательном процессе особую важность приобретает развитие знаний и навыков, ориентированных на инженерную и конструкторскую деятельность. В статье освещаются ключевые факторы развития проектно-конструкторской компетентности, такие как методы обучения, цифровые технологии, интеграция с практикой и развитие креативного мышления. Также рассматривается эффективность современных педагогических технологий и инновационных подходов, а также пути их внедрения в образовательный процесс. Результаты исследования способствуют повышению качества и эффективности образования в инженерно-технических направлениях.*

Ключевые слова: *проектно-конструкторская компетентность, инновационный подход, цифровые технологии, творческое мышление, педагогические технологии.*

Annotatsiya: *Ushbu maqolada talabalarning loyihalash-konstruktorlik kompetentligini rivojlantirishning asosiy sifatlari va tamoyillari tahlil qilinadi. Bugungi kunda ta’lim tizimida muhandislik va konstruktorlik faoliyatiga yo‘naltirilgan bilim va ko‘nikmalarni rivojlantirish muhim ahamiyat kasb etmoqda. Maqolada loyihalash-konstruktorlik kompetentligini rivojlantirishda ta’lim metodlari, raqamli texnologiyalar, amaliyot bilan integratsiya va ijodiy fikrlashni rivojlantirish kabi asosiy omillar yoritib berilgan. Shuningdek, zamonaviy pedagogik texnologiyalar va innovatsion yondashuvlarning samaradorligi tahlil qilinib, ularning ta’lim jarayoniga tatbiq etish*

yo‘llari ko‘rib chiqiladi. Tadqiqot natijalari muhandislik va texnik yo‘nalishlarda ta’lim sifati va samaradorligini oshirishga xizmat qiladi.

Kalit so‘zlar: *loyihalash-konstruktorlik kompetentligi, innovatsion yondashuv, raqamli texnologiyalar, ijodiy fikrlash, pedagogik texnologiyalar.*

Introduction. In today's world, the rapid development of technological progress necessitates increased attention to engineering and design disciplines within the education system. In modern economies and industrial sectors, innovative projects, engineering solutions, and creative design approaches play a crucial role. Therefore, preparing students for design and engineering activities and developing their relevant competencies is a pressing issue.

Several factors play an important role in the development of students' design and engineering competencies. These include the application of advanced pedagogical technologies, the integration of digital and innovative technologies, the expansion of practical and laboratory sessions, the development of engineering approaches, and encouraging students toward independent creative thinking.

The main factors contributing to the development of students’ design and engineering competencies are as follows:

1. **Theoretical knowledge**:
   - Fundamentals of engineering and technology
   - Principles of design and construction
   - Understanding and creating technical drawings and documentation
2. **Practical skills**:
   - Drafting, modeling, and programming (AutoCAD, SolidWorks, MATLAB, etc.)
   - Conducting experimental design and testing
   - Working with digital technologies and innovative software
3. **Creative and critical thinking**:
   - Problem-solving skills
   - Ability to apply and adapt to new technologies
   - Creating new designs and projects
4. **Teamwork and communication**:
   - Skills for working in project teams
   - Clearly expressing technical ideas and giving presentations
   - Communicating and collaborating in a professional environment
5. **Independent learning and experience**:
   - Self-development and learning new technologies
   - Interest in scientific research
   - Developing independent engineering and design activities
6. **Innovative and technological factors**:
   - Utilizing modern production technologies
   - Enriching lessons through digital technologies and simulations

- Integrating engineering and creative processes using the STEAM approach

These factors help students become effective and competitive in the field of design and engineering.

This article analyzes the key factors that influence the development of students’ design and engineering competencies. It also examines the effectiveness of modern educational methods and innovative approaches and provides practical recommendations for their integration into the educational process. The results of the study contribute to improving the quality and efficiency of education in engineering and technical disciplines.

Literature analysis. The issue of developing students’ design and engineering competencies has been widely studied by scholars and researchers around the world. Scientific research in this area covers aspects such as pedagogy, engineering education, the integration of innovative and digital technologies into the educational process. Below is an analysis of key studies and literature on the topic:

1. **Pedagogical approaches and methodological research**:

- *J. W. Thomas* conducted research on integrating Project-Based Learning (PBL) into the educational process. His work explored how involving students in project activities can enhance their problem-solving skills.
- *D. H. Jonassen*, in his work "Designing Constructivist Learning Environments", analyzed the effectiveness of the constructivist approach in developing design and engineering competencies.
- *J. L. Kolodner* studied how cognitive science and project-based learning methods can enhance students' design abilities.

2. **Research on engineering and technical education**:

- *Felder & Brent*, in their book *"The ABCs of Engineering Education"*, discussed the importance of project-based learning in engineering education and its impact on students' independent engineering thinking.
- *L. Dym et al.*, in *"Engineering Design Thinking, Teaching, and Learning"*, analyzed modern teaching methods in engineering design.
- *Prince & Felder* examined the outcomes of incorporating active learning methods such as hands-on projects and teamwork into engineering education.

3. **Digital technologies and innovative approaches**:

- *S. Papert*, in *"Mindstorms: Children, Computers, and Powerful Ideas"*, demonstrated the potential of programming and technology in developing students' design skills.
- *M. Resnick* studied ways to engage students in engineering and design activities using visual programming environments like Scratch.
- *B. Kim & R. Reeves*, in their research *"Reengineering Engineering Education with Virtual Laboratories"*, presented ways to enhance engineering education through the use of virtual labs.
- *G. Fischer*, in *"Computational Literacy and Design Thinking"*, analyzed the advantages of computerized design environments for students.

4. **STEAM education approach and creative thinking**:

- *G. Yakman* conducted research on integrating the STEAM (Science, Technology, Engineering, Arts, Mathematics) model into education and proved its significance in developing design and engineering competencies.
- *Bequette & Bequette*, in their article *"A Creative Approach to Teaching Engineering"*, presented research results on the integration of art and design in advancing engineering education.

Scientific studies by these scholars show that:

- Innovative pedagogical approaches (project-based learning, problem-based learning, research-based education) play a vital role in competency development.
- Digital technologies and virtual laboratories contribute to making the learning process interactive and improving students' engineering skills.
- The STEAM approach enhances student creativity and supports better assimilation of design and engineering tasks.

Based on the analysis of these academic sources, the article offers specific recommendations for applying modern approaches to develop students' design and engineering competencies.

Materials and Methods. To explore the topic of the key factors in developing students’ design and engineering competencies, the following methods can be used:

1. Theoretical-analytical method Purpose: To study the scientific and theoretical foundations of design and engineering competencies; to analyze pedagogical technologies and innovative approaches.
Application: Analyzing scientific sources and pedagogical research related to technological advancement; studying literature on modern competency-based approaches, engineering education, and creative thinking.

2. Empirical research methods Purpose: To identify and evaluate practical processes in developing students' design and engineering competencies; to assess the effectiveness of the educational process and determine directions for improvement.

Application:

- **Surveys and interviews:** Understanding students’ and teachers’ attitudes toward project-based activities.
- **Observation:** Observing students' design activities and identifying their challenges.
- **Pedagogical experiments:** Testing different methods and studying their effects.

3. Diagnostic and assessment methods Purpose: To identify students’ engineering competencies and assess their development dynamics; to determine the effectiveness of methodological interventions.

Application:

- **Tests and assessment criteria:** Evaluating students' knowledge and skills.
- **Portfolios:** Analyzing projects created by students.
- **Expert evaluation:** Assessing student work by experienced specialists.

4. Innovative approaches Purpose: To develop design and engineering competencies using modern technologies; to enhance students’ creative and engineering skills through practical engagement.

Application:

- **Digital technologies:** Use of CAD software, 3D modeling, simulations, and virtual labs.
- **STEAM approach:** Integrating elements of science, technology, engineering, art, and mathematics.
- **Problem-based learning:** Engaging students in solving real-world problems.

5. Statistical analysis methods Purpose: To verify the reliability of research results; to determine the effectiveness of experimental impact.

Application:

- Comparing results of experimental and control groups.
- **Mathematical-statistical analysis:** Analyzing and generalizing obtained results using statistical methods.

These methods ensure the scientific validity of the article, cover both theoretical and practical aspects, and allow for an in-depth analysis of the process of developing students’ design and engineering competencies.

Results. As a result of this article, the main factors influencing the development of students' design and engineering competencies will be identified, and scientific-theoretical and practical recommendations for their development and improvement will be proposed. Additionally, the effectiveness of modern innovative technologies and pedagogical approaches will be evaluated, and strategic suggestions for their application in the educational process will be provided.

The results expected from the article on the topic of the main factors of developing students' design and engineering competencies include the following:

1. Theoretical results. The scientific foundations of design and engineering competencies will be identified; the key theoretical concepts related to the competency-based approach will be systematized; methods for developing students' competencies in the integration of engineering education will be outlined; the main factors influencing design and engineering competencies will be analyzed; the impact of innovative technologies and digital tools will be identified; the importance of practical experience, creative thinking, and teamwork will be studied.

2. Practical results. Effective educational and methodological recommendations for students will be developed; innovative teaching and methodological materials on design and engineering will be prepared; effective methods for engaging students in design and engineering activities will be proposed; the methodology for developing design and engineering competencies using modern technologies will be improved; methods for applying 3D modeling, CAD software, and simulations in the educational process will be developed; strategies for solving practical problems through the STEAM approach will be devised.

3. Pedagogical results. The effectiveness of developing design and engineering competencies will be evaluated; criteria for assessing students' competencies will be identified and implemented in practice; the results of experimental and control groups will be analyzed; the development of students' knowledge, skills, and competencies will be observed; the outcomes of independent design and engineering work will be studied; projects created by students will be assessed in terms of quality.

4. Innovative results. The effectiveness of innovative teaching methods and technologies will be identified; new methodologies and interactive technologies will be introduced into the educational process; the potential for integrating design and engineering activities into curricula will be explored; digital technologies and interactive approaches will be widely implemented in pedagogy; virtual laboratories, simulations, and digital teaching platforms will be developed. Problem-based learning methods will direct students' creative thinking.

As a result of the article, an effective model for the formation and development of students' design and engineering competencies will be proposed, based on scientific-theoretical, practical, and innovative approaches. Additionally, recommendations for improving the educational process in this field will be provided.

Discussion. The development of students' design and engineering competencies is one of the key areas in modern technical and engineering education. Today, identifying the factors influencing the formation of this competency and utilizing them effectively is crucial for enhancing the quality of education and preparing students for practical engineering activities.

1. Key Factors Influencing the Development of Competency:

The following factors play a significant role in the development of students' design and engineering competencies:

- **Innovative Technologies and the Digital Environment:** In modern education, technologies such as 3D modeling, artificial intelligence, virtual, and augmented reality can enhance students' technical skills in creating engineering designs.
- **Practical Training and Project Activities:** To reinforce theoretical knowledge, students must participate in real engineering projects and create independent engineering designs.
- **Problem-Based Learning and Creative Thinking Development:** Using a problem-based learning approach (PBL) is crucial for enhancing students' creative and critical thinking abilities. Through this method, students learn to analyze real-life problems and develop innovative solutions.
- **Teachers' Professional Skills and Teaching Methodology:** Modern pedagogical technologies, project-based approaches, and mentoring systems play an important role in working with students. When teachers use interactive and experimental teaching methods, they motivate students to develop their independent projects.
- **Collaboration with Industry and Real Production Experience:** When students participate in production companies and startup projects, it significantly influences the

development of their design and engineering competencies. University-industry collaboration is important for adapting students to market conditions.

2. Discussion and Suggestions:

To further enhance the development of design and engineering competencies, the following suggestions can be made:

- Widespread use of hybrid and digital technologies in engineering education.
- Involvement of students in real projects and startup activities.
- Increase practical lessons to develop analysis and problem-solving competencies.
- Strengthen education and industry collaboration to bring students closer to production processes.

The development of students' design and engineering competencies is a multifactorial process in which innovative technologies, practical teaching methods, collaboration with industry, and problem-based approaches play a key role. The synergy of these factors enables students to gain skills in independent work in modern engineering environments, creative approaches to project development, and solving real problems.

Furthermore, the integration of industry, increasing experience and practical training, and the use of advanced technologies are crucial for the development of students' competencies. As a result, the ability to train competitive, innovative thinkers with practical skills will increase.

Conclusion: This article analyzes the main factors influencing the formation and development of students' design and engineering competencies. The research identifies the following key points:

- Innovative technologies, practical training, and problem-based learning approaches play a vital role in developing design and engineering competencies.
- To enhance students' technical creativity, it is essential to integrate modern teaching methods, including 3D modeling, simulations, and digital technologies, into the educational process.
- The development of competencies relies on both theoretical knowledge and practical experience, as well as independent project activities.
- When innovative approaches, including distance learning and hybrid teaching methods, are introduced into the educational process, students acquire more effective skills in design and engineering.
- By improving competency assessment criteria, it is possible to identify the dynamics of students' knowledge and skills development, thereby enhancing the quality of education.

Overall, this article presents the scientific-theoretical foundations for the development of students' design and engineering competencies, reveals the effectiveness of innovative pedagogical approaches, and provides practical recommendations for their integration into the educational process.

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