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Intensive Methods For Developing Design Skills In The Professional Activities Of Engineering Students

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Abstract
The article provides a detailed and comprehensive analysis of the role of engineering and computer graphics in the professional training system of engineering students, as well as the mechanisms for developing graphic design skills. Nowadays, the advancement of engineering demands extensive application of new-generation technical equipment, devices, and modern digital technologies. Accordingly, the theoretical and practical aspects of forming 2D and 3D design skills related to industry-specific equipment, products, and parts among engineering students are thoroughly examined in this research.
The author systematically analyses existing challenges in the educational process, including students' difficulties in applying theoretical knowledge in practice, insufficiently developed software application skills, and ineffective use of pedagogical methods during teaching. To address these issues, the author proposes the implementation of modern pedagogical technologies, engaging students in small-group project-based and practical assignments, and systematically organizing practical classes using specialized computer graphics software (such as AutoCAD, SolidWorks, and Compass 3D). Furthermore, the scientific and practical importance of extensively employing interactive methods that enhance students' independent work and critical thinking skills—such as Project-Based Learning, trainings, and intensive practical sessions—is substantiated. Additionally, the article outlines specific criteria developed to evaluate the effectiveness of the proposed methods and approaches, demonstrating their potential to improve students' professional competencies, design speed, and quality. As a result, it is emphasized that these approaches will significantly develop students' innovative, creative, and analytical thinking abilities, consequently broadening opportunities for preparing competitive engineering professionals in alignment with the requirements of the labor market.
Keywords: engineering education, computer graphics, graphic design, 2D and 3D modeling, project-based learning, professional competencies, digital technologies, practical skills, pedagogical technologies, innovative education, critical thinking.

Introduction

Currently, the engineering field has become one of the leading sectors of our national economy, and there is an increasing daily demand for highly qualified professionals capable of effectively applying modern digital technologies within the industry. This, in turn, requires higher education institutions in engineering to develop scientifically-grounded approaches for the formation and enhancement of students' professional competencies.
One of the most essential professional skills in engineering practice is graphic design. The extensive use of computer graphics and contemporary information technologies plays a crucial role in developing precise and high-quality graphic representations for engineering projects, new equipment, products, and various components.
However, in practice, many engineering students face various challenges in integrating theoretical knowledge with real-world practice. Specifically, difficulties arise in mastering 2D and 3D graphic design skills and software applications, along with inadequately developed independent working abilities and limited opportunities for fully developing creative thinking. Therefore, developing effective and intensive methods, as well as implementing them into the educational process, is critically important for further improving engineering students' knowledge and practical skills in graphic design.
Accordingly, this article provides a comprehensive analysis of the existing problems in developing graphic design skills among engineering students, thoroughly examining their causes and consequences. As solutions to these issues, scientifically grounded intensive methods such as modern pedagogical approaches, innovative educational technologies, and Project-Based Learning are proposed. Implementing these methods is expected

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to enhance students' professional competence, ensure their competitiveness in the future labor market, and contribute significantly to creating innovative engineering products.

The effectiveness and outcomes of education systems in the world's most developed countries are reflected in their high socio-economic, technical, technological, and agricultural achievements. The intellectual workforce represents the backbone and foundation of economically advanced nations. This workforce demonstrates its competence through the development of independent working abilities, graphic competencies, design skills, and creative thinking within educational processes. In continuous education, mastering design-graphic knowledge through innovative methods, particularly in disciplines like "Engineering and Computer Graphics," significantly contributes to enhancing students' spatial imagination, creativity, and the overall effectiveness of graphic education.

Currently, applying multimedia and computer technologies in teaching "Engineering and Computer Graphics" is crucial for fostering students' design competencies.

In Uzbekistan, consistent reforms within the educational system have led to the development of the Higher Education System Concept for 2030. This concept places particular emphasis on preparing students for innovative activities, professional orientation, and project-design work. In engineering specializations, developing students' design skills to generate innovative ideas and encourage creative thinking has become a critical requirement on today's educational agenda.

Degree of study of the problem

Issues related to the methodological improvement of graphic education, the development of students' graphic design competencies, graphic thinking, and spatial imagination have been studied extensively by several Uzbek scholars, including R.Khorunov, I.Rahmonov, A.Kholmirzaev, Sh.Murodov, D.Kuchkarova, R.Ismatullaev, T.Rikhsiboev, E.Ro'ziev, A.Khamrakulov, S.Saidaliev, A.Qahharov, Sh.Dilshodbekov, D.Achilova, Ch.Shokirova, N.Yadgarov, and others. Their research has significantly contributed to the advancement of teaching methods in disciplines such as "Descriptive Geometry and Engineering Graphics," "Technical Drawing," and "Engineering and Computer Graphics."

In addition, prominent foreign scholars, such as I.P.Istomina, L.V.Zanfirov, L.P.Rusinov, A.V.Piliper, Yu.A.Volkova, A.I.Khubiev, L.N.Anisimov, P.A.Ostrozhkov, Zh.Zh.Janabaev, Charles A. Rankovskiy, Minaruth Galey, Neda Bokan, Marko Ljucovich, Srdjan Vukmirovich, Ramon Rubio García, Javier Suárez Quiros, Ramón Gallego Santos, Santiago Martín González, Samuel Moran Fernanz, Putz C., Rodriguez de Abajo, F.J., Rubio R., Toledo E., Martinez M.X., James L. Mohler, Bertoline G., Burton T., Wiley S., Bishop J., Dejong P.S., have also made considerable contributions to the research on teaching engineering graphics, fostering graphic design competencies, and developing innovative pedagogical strategies.

However, despite these extensive studies, the analysis indicates that insufficient research has been conducted specifically on industry-oriented graphic design issues. Particularly, graphic design in specialized educational fields such as agriculture, transport, and related areas remains understudied. Consequently, exploring graphic design within these distinct fields emerges as a critical and promising area for future research endeavors.

Discussion

The design competence of future engineers represents an integral quality composed of motivational, intellectual, practical-activity-based, and creative components. This competence manifests itself through the effective acquisition and application of knowledge, skills, and abilities essential for professionally relevant design activities. Furthermore, it facilitates meaningful cognitive activities across various directions and allows for the creative solution of project tasks of differing complexity levels [22].

In essence, design encompasses the processes of identifying, investigating, and resolving complex problems, along with organizing activities aimed at presenting formalized solutions effectively. Additionally, design activities actively promote continuous knowledge enhancement, consolidation of theoretical understandings, and refinement of practical skills [23].

In our definition, to systematically implement the design process among students, it is particularly important to pay special attention to the following aspects: mastery of design activity methods; collection and analysis of factors related to design activities; independent study, monitoring, and quality analysis of executed projects; and making effective efforts to implement projects practically [23].

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Design is a specific form of engineering activity that involves creating projects aimed at manufacturing structures. In turn, constructing is considered a particular stage within the overall design process, comprising the creation of multiple structural variants, calculations, and step-by-step operations [21].

Design skills encompass a comprehensive set of knowledge based on engineering principles. For future engineers, these skills involve identifying problems within their professional field, designing solutions that meet evolving technological requirements through specialized knowledge and competencies, and synthesizing knowledge related to their area of activity. Such competencies ultimately guide individuals toward personalized solutions to practical problems.

For example, when teaching the "Engineering and Computer Graphics" course in agricultural education directions, it is essential to educate students about designing mechanisms, parts, and equipment related to agriculture. Specifically, training students in the virtual modeling of tractor spare parts and additional agricultural equipment significantly enhances their professional competencies through interdisciplinary integration.

Results

In organizing educational processes for the course "Engineering and Computer Graphics," the following approaches have been identified:

Traditional method: Drawing on the board with chalk or markers.

Non-traditional method: Demonstrating the sequential implementation steps using multimedia presentations.

Modern method: Modeling the drawings of studied projects and conducting editing tasks interactively with student participation. During this method, it is advisable to use relatively simple drawings. Teachers must ensure adherence to lesson technological maps regarding timing. Research by V.V. Kondratova scientifically substantiates the application of computer graphics in educational practice, emphasizing the effectiveness of displaying computer-generated models of parts during lessons.

Through incorporating software in both lectures and practical classes of the "Engineering and Computer Graphics" course, the following outcomes can be achieved:

1. Students acquire an understanding of the significance, objectives, and tasks of the course, gaining clarity about its importance within their chosen educational direction.
2. Students develop foundational conceptual understanding of the subject.
3. Students enhance creativity, independent, and logical thinking skills.
4. Students acquire knowledge intended for independent learning and develop practical graphic drawing skills.
5. Students fulfill subject requirements effectively, gaining the necessary knowledge and practical skills essential for the course.

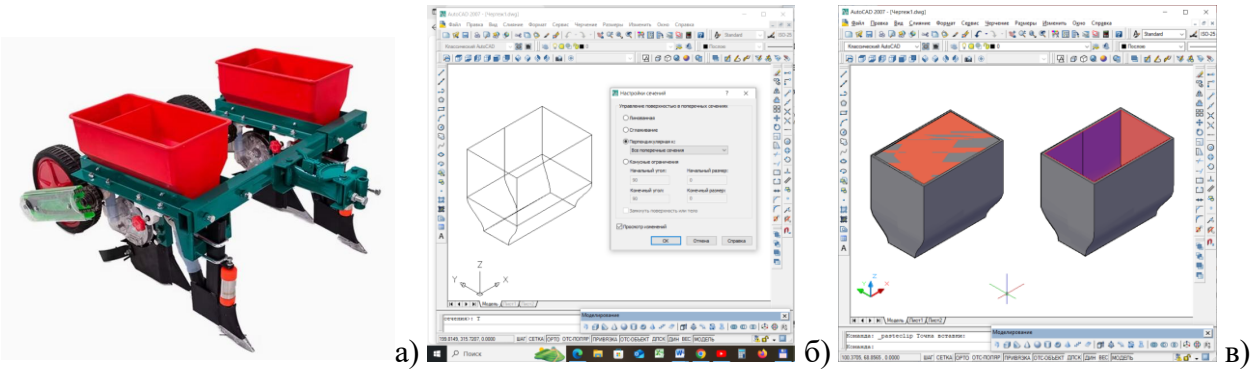

Figure 1. *(a) The model of a planting apparatus currently used in agriculture; (b) 2D modeling of this apparatus in AutoCAD software; (c) 3D modeling of the selected component.*

Figure 1 illustrates the modeling process of the presented apparatus using computer graphics. Teaching this modeling approach to students enables them to analyze designs thoroughly and encourages creative approaches and innovative solutions.

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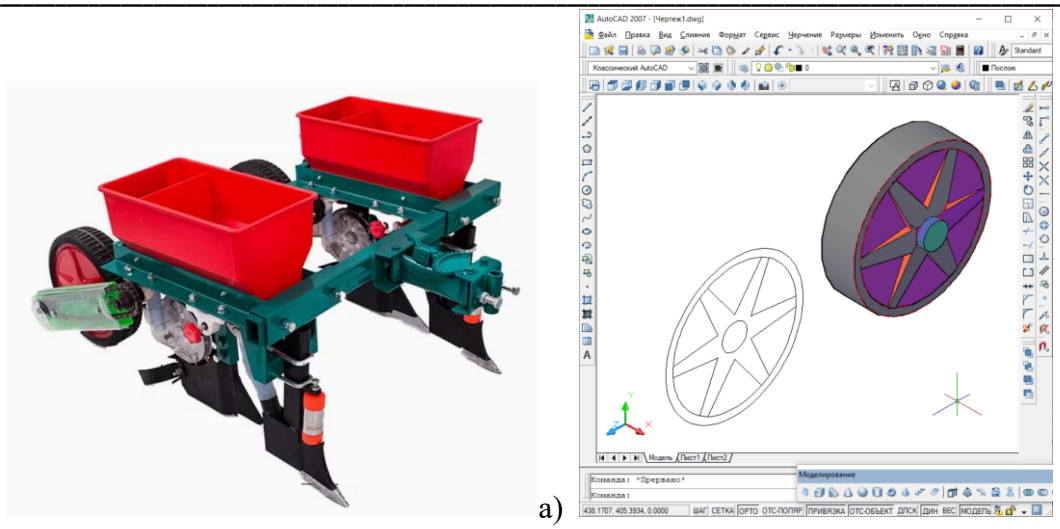

Figure 2. *(a) Model of a planting apparatus currently used in agriculture; (b) 2D and 3D modeling of the gearbox component from this model using AutoCAD software.*

Figure 2 demonstrates the modeling process of an agricultural planter wheel. Using computer-based virtual design tools enables the accurate modeling of sector-specific components. Through computer-aided design, students effectively acquire essential knowledge, skills, and competencies related to engineering project design and construction activities. Undoubtedly, emphasizing interdisciplinary integration during teaching fosters the development of new ideas and innovations, significantly benefiting the field.

Practical Application. In teaching "Engineering and Computer Graphics," prioritizing the development of students' design skills by creating and editing two- and three-dimensional models of sector-specific drawings greatly enhances professional competencies. Particularly in agricultural education directions, course projects and graduation qualification works should aim to fully utilize digital tools for modeling construction projects through computer graphics. Ultimately, future engineers will operate within manufacturing enterprises and design organizations. Consequently, fully integrating sector-specific drawings into computer graphics modeling at the higher education level enables students to better demonstrate their professional knowledge in practice.

Currently, Namangan Technical University is actively conducting scientific research in this direction. During pedagogical experiments, the comparative analysis of results at the beginning and end of a semester revealed that 8 students (19.5%) executed tasks without errors, 12 students (29.3%) made minor errors or inaccuracies, 17 students (24.4%) selected correct projection methods but made some design errors, while 4 students (48.8%) exhibited multiple errors in projection methods and various other issues. Nevertheless, it was observed that students' interest in design and professional knowledge increased significantly—from 50% to 88%.

Conclusion

In organizing the educational process for the "Engineering and Computer Graphics" course, it is first necessary to present knowledge to students in an accessible and straightforward manner. On this basis, methodological support compatible with various educational forms and methods should be created to develop high-level skills and competencies. To enhance the effectiveness of education, it is critical to continually improve the process and systematically monitor students' progress indicators. By fully implementing the tasks defined for "Engineering and Computer Graphics," it becomes possible to establish conditions in which students effectively acquire and apply subject-specific knowledge in practice. Additionally, extensive use of computer graphics in students' professional design activities promotes increased creativity and efficiency, resulting in the intensive development of students' design competencies.

The subject "Engineering and Computer Graphics" plays a significant role in the development of professional competencies among engineering students. The extensive application of modern digital and multimedia technologies within the educational process effectively promotes the formation of students' design skills, spatial imagination, and creative thinking. In particular, the creation of 2D and 3D models of sector-specific

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constructions, parts, and equipment using computer software (such as AutoCAD) facilitates the seamless integration of theoretical knowledge with practical skills.

The results obtained through this research underscore the necessity of using intensive methods to develop graphic competencies and design skills among students. Interdisciplinary integration, industry-oriented practical activities, and the systematic application of computer graphics are of crucial importance in this regard. Experimental outcomes have demonstrated that incorporating contemporary methods into the educational process significantly enhances students' professional knowledge, practical skills, and interest in design activities.

Therefore, it is recommended to continuously improve educational methodologies, widely implement innovative pedagogical technologies, and employ comprehensive approaches aimed at developing students' graphic competencies. Such measures will contribute substantially to preparing highly qualified, competitive engineering specialists who meet the evolving demands of the labor market.

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