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ИЗДАТЕЛ:
Съюз на учените в България - клон Сливен
Бюро на СУБ – клон Сливен
Председател:
Михаела ТОПАЛОВА
Зам.-председател:
Д-р Юлия БЯНКОВА
Секретар:
Мина ЦОНЕВА
Членове на бюрото:
Марина НИКОЛОВА
Магдалена ПАВЛОВА

Адрес на издателството:
Бул. "Бургаско шосе" № 59,
8800 Сливен, България, тел: +35944667549,
e-mail: sub_sliven@abv.bg

PUBLISHER:
Union of scientists in Bulgaria - branch Sliven
Advisory Boardof USB – branch Sliven
Chairwoman:
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Publishing House Address:
59, Bourgasko shousse Blvd
8800 Sliven, Bulgaria, tel: +35944/667549
e-mail:sub_sliven@abv.bg

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Pedagogical sciences

ENGINEERING EDUCATION IN THE AGE OF TECHNOLOGY - INNOVATIVE APPROACHES FOR ACTIVE STUDENT PARTICIPATION

Monika Simeonova-Ingilizova[1*], Yordanka Slavcheva[2]

[1] Technical University of Sofia, Faculty of Engineering and Pedagogy – Sliven
Department of Pedagogy and Management, e-mail: monikaingilizova@gmail.com
* - corresponding author

[2] Technical University of Sofia, Faculty of Engineering and Pedagogy – Sliven
e-mail: yotoslav@abv.bg

Abstract:
This article examines the importance of engineering education in the age of technology and presents innovative approaches to active student participation through the use of computer-aided design, modeling, and drafting software. The modern world is experiencing rapid advances in information technology, automation, and robotics, necessitating the need to update engineering education to meet new technological challenges.
Through successful examples and analysis of the challenges and opportunities associated with technology in engineering education, the article aims to promote the exchange of ideas and best practices. Engineering education needs to be adapted and changed to meet the new demands of the modern world by stimulating active student participation and developing their engineering skills and competencies. The aim is to prepare future engineers for successful careers in high-tech industries and to create innovations that will contribute to the public good.

Keywords: *engineering education, technological challenges, innovative approaches, computer aided design software, modelling, drawing, technological progress.*

INTRODUCTION

Engineering education is a process in which students' knowledge, skills and competencies in engineering are formed and consolidated. It aims to prepare them for professional careers in engineering science and technology. Engineers occupy an important place in public life through the design, development, construction and maintenance of various systems, machines, equipment and technologies.

The education of engineering professionals is critical to the development of technology, innovation and industrial progress. It plays an important role in creating new products and services, improving living standards and solving social and environmental challenges. It plays a key role in the age of technology, where the changing technological environment requires new skills and competences from future engineers. The modern world is characterised by significant advances in information technology, automation and robotics that are changing the way engineering solutions are designed, modelled and drawn [5].

Engineering education usually includes the theoretical study of basic sciences such as mathematics, physics and chemistry, as well as specialized disciplines such as electrical engineering, mechanical engineering, chemical engineering, information technology, etc. Students are introduced to the basic principles and concepts of their field and acquire practical skills through laboratory exercises, projects and internships.

Technologies such as computer-aided design, modeling, and drafting software offer innovative approaches and tools that can enhance students' active participation and prepare them for the real-world challenges that lie ahead in engineering practice. Training engineers not only develops technical skills but also encourages analytical thinking, problem solving, creativity and a team working approach. Students

learn to analyze complex cases, design and develop innovative solutions, work in teams and communicate effectively.

The relevance of the issue at hand is multifaceted and based on several key factors:

Change of technological environment – the modern world is experiencing rapid progress in information technology, automation and robotics. These changes are affecting the way engineers work and solve problems. It is therefore essential that engineering education is updated and adapted to these new technological challenges.

Industrial needs – changes in high-tech industries require engineers to possess a wide range of skills and competencies, including proficiency in computer-aided design, modelling and drafting software tools. Engineers need to be able to create innovative solutions and products, making up-to-date consideration of technology in engineering education of the utmost importance.

Student engagement – today's students were born in the digital age and have different expectations and preferences for the learning process. Interactivity, engagement and real-world experience are becoming key factors for successful learning. The use of software tools for computer-aided design, modelling and drawing can stimulate student participation and motivation, providing them with the opportunity to apply theoretical knowledge to practical realities.

Global Competitiveness – in a global economy where technology is central, competition between countries and industries is intensifying every day. To be competitive, countries need to develop highly skilled engineers who can adapt to changing technological demands and be innovators. Engineering education based on innovative approaches and the use of modern software tools plays a key role in developing such engineers and in preparing them for future challenges.

Public good – engineering has a significant impact on society and the environment. Engineers are responsible for creating innovations that can improve the quality of life and solve social, environmental and economic problems. By introducing innovative approaches to engineering education and actively involving students in technology-related issues, new solutions can be generated that will contribute to sustainable development and the well-being of society.

All of this defines the purpose of the research, which is to encourage the education community to rethink approaches to engineering education and integrate innovative methods that prepare students for the modern challenges and opportunities provided by technology.

REVIEW OF SCIENTIFIC LITERATURE

Popular software packages used in engineering education

In engineering education there is a wide range of software packages that are used for computer aided design, modelling and drafting. Here are some examples of popular software packages that are used in engineering education:

AutoCAD – one of the most well-known and widely used software packages for computer aided design and drafting. It provides powerful tools for 2D and 3D model creation, drawing editing and project visualization.

SolidWorks is a software package that is used for computer-aided design of 3D models. It offers a wide range of tools for creating complex mechanical and electrical systems, simulating model behavior, and creating technical documentation.

CATIA is one of the leading platforms for computer-aided design and modeling in engineering. This software provides a variety of tools for creating 3D models, designing products, and collaborating in teams.

MATLAB is a powerful engineering software that is used for mathematical calculations, data analysis, simulations and modelling. It provides a rich library of functions and tools for working with numerical and graphical data.

ANSYS is an engineering analysis software package used for simulations of various physical and engineering processes. It offers simulation capabilities for structural behavior, thermal and electrical properties, dynamic responses, and other aspects of engineering design.

Depending on the specific needs and area of engineering, other software packages such as **Pro/ENGINEER, Autodesk Inventor, NX** and many others can also be used.

It is important to note that the choice of software depends on the specific requirements of a project. These software packages play a critical role in preparing students by providing them with the tools and skills necessary to create complex and precise engineering models. They also help students become familiar with standard processes and practices in the engineering industry and develop their problem-solving, collaboration and team communication skills.

The most popular universities in the world that use AutoCAD in the education of engineering students: [6]

Massachusetts Institute of Technology (MIT) – one of the world's most prestigious universities, offering a host of engineering programs using the engineering industry's leading design, drafting and visualisation software.

University of Texas, Austin – offers a variety of engineering programs including computer systems engineering, mechanical engineering and electrical engineering. In many of these programs, the technology tool mentioned earlier is used as a design and visualization tool.

University of Birmingham in the United Kingdom – offers multiple engineering programs including mechanical engineering, electrical engineering and civil engineering. It is also used as a design and visualization tool in many of these programs.

University of California, Los Angeles (UCLA) uses the company's Autodesk engineering drafting and design program in various engineering programs such as electrical, mechanical, and civil engineering.

University of Alabama (UA) also applies the popular software to the mechanical engineering curriculum. University faculty summarized that this improves students' skills in creating designs and schematics for mechanical systems and devices.

University of Bristol in the United Kingdom uses engineering design and visualization software in the mechanical engineering program. According to university faculty, its use facilitates the design of machines and components and improves students' ability to create technical drawings and schematics.

Delft University of Technology, The Netherlands in various engineering programs, such as civil engineering and architecture the recognized computer aided design program is applied. Students use the software to create drawings, 2D and 3D models, and to analyze engineering structures.

Stanford University, USA in various engineering programs, students have the opportunity to create 2D and 3D drawings and models, explore spatial relationships, and conduct analyses of their designs using computer software.

University of Nottingham, United Kingdom in its engineering programs, uses it as a basic drawing and design tool. Students learn various features of the software and apply them to projects in various engineering disciplines.

METHODOLOGY

A methodological approach combining qualitative and quantitative methods is used to carry out this research.

A survey of existing literature and published sources was carried out to understand the current state of attitudes towards the use of AutoCAD in the educational process of future engineers in other parts of the world and in this country.

The following is a qualitative study that includes discussion and observations with faculty and students, respectively, who actively use AutoCAD in the learning environment.

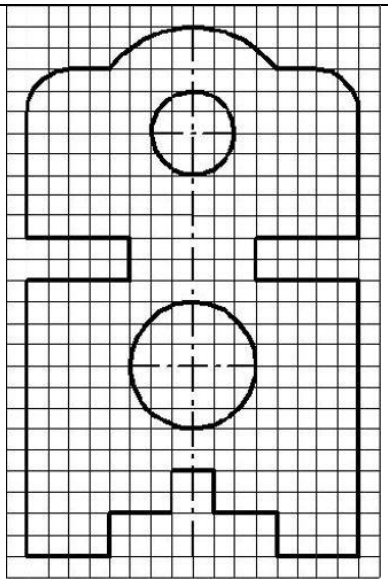
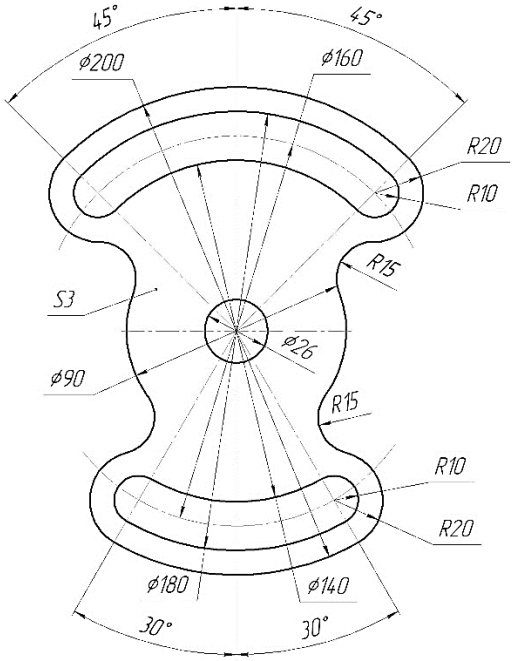
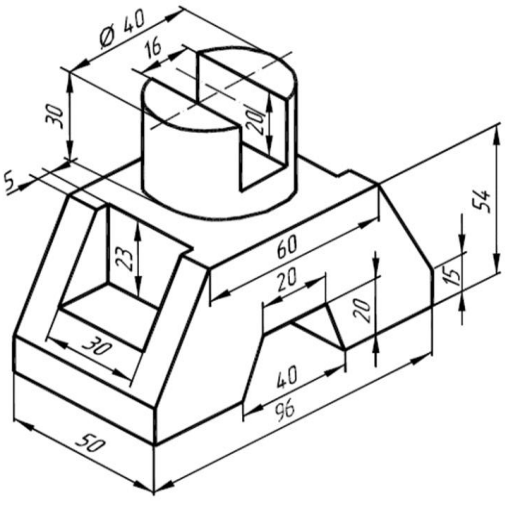
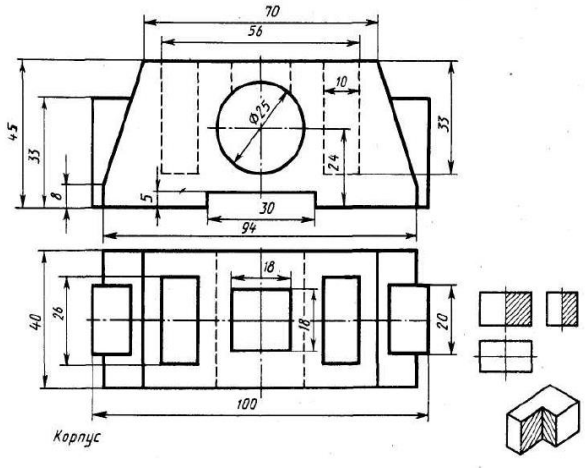
After analyzing the criteria and indicators from the observation during the learning process, with effective use of AutoCAD, the results achieved are presented.

The final step in the methodology involves the collection and analysis of quantitative data, through evaluations, which will be used to assess the impact and effectiveness of the use of the popular AutoCAD design and drafting program in the learning environment.

RESEARCH RESULTS

The study was conducted with 62 engineering students, from two consecutive classes, respectively in two consecutive academic years

Table 1

Draw a geometric figure and plot the necessary dimensions.	***1:1 scale drawing of a workpiece, on which the smooth transitions are to be drawn using geometric constructions.***
 E. Lapteva , Yushina S.V., Educational-methodical complex of discipline, Engineering Graphics 1, Petropavlovsk, 2011. [3]	 Talalai P., S. Galushkin, S. Ignatyev, D. Levashov, Engineering Graphics: General rules of execution of drawings. Textbook, St. Petersburg State Mining Institute, 2010 – 70 c., UDC 622:744(075.83) [4]
Construction of three images according to a given axonometric projection of a workpiece.	***Construct three images according to two projections of a part.***
 Kaigorodtseva N.,L.M. Leonova, Engineering Graphics.Initial data of calculation and graphic works, Omsk, 2007. [2]	 Vasilieva, M., O. Cherdintseva, O. Shevchenko, Engineering Graphics. Geometric constructions of images of spatial models: textbook, Orenburg, 2006 - 104 p. [1]

In the course of their studies, students develop course assignments that gradually introduce them to the material to be learned. This creates a smooth transition of adaptation, a gradual acquisition and

assimilation of new knowledge, skills and habits. Each subsequent assignment reinforces and builds on the previous one. In the work of the students, mutual assistance, teamwork, sharing the knowledge learned with each other, solving situations created in the process of work are manifested and developed. This alone can inspire gratitude, pride and respect. Some of the tasks that students perform in the course of their engineering studies are presented in Table 1:

Results of the observation.

The observation took place during the learning process considering the following criteria and indicators mentioned in Table 2:

Table 2

CRITERIA	LINKS
Criterion 1: Technical skills in working with AutoCAD	***Indicator 1:*** Ability to create and edit 2D objects such as lines, circles, polylines and text. ***Indicator 2:*** Ability to use sophisticated AutoCAD tools and commands, such as basic transformations, sectioning and cropping, or adding embellishments, etc. ***Indicator 3:*** Compliance with specified codes and standards for design and drawings
Criterion 2: Creativity and design skills	***Indicator 1*:** Ability to design and create innovative and functional designs in AutoCAD. ***Indicator 2:*** Ability to add details, textures and colors that enhance the visual aspect of projects. ***Indicator 3:*** Ability to develop different options and alternative solutions for a given task.
Criterion 3: Collaboration, team communication when working with AutoCAD and project management	***Indicator 1:*** Ability to communicate and collaborate effectively with team members while working collaboratively with AutoCAD, including exchanging CAD files, coordinating tasks, and clearly expressing ideas and requirements. ***Indicator 2:*** Ability to create and manage projects in AutoCAD, including file structure organization and working with templates. ***Indicator 3:*** Ability to track deadlines and manage time effectively when working on projects in AutoCAD.

Figure 1 presents the results of the observation, with the impression that the students have a desire to improve their professional skills, which is why they show great interest in working with AutoCAD and make the necessary voluntary efforts to master the knowledge and apply it in practical tasks.

In the first criterion „Technical skills in working with AutoCAD“ 98% of the students show quick adaptation in the learning process, create and edit 2D objects using lines, circles, polylines and text. But the ability to use sophisticated AutoCAD tools and commands by making basic transformations, sections and cropping or adding decorative elements is shown by only 74% of students. Probably the fast pace at which the educational process itself takes place influences the indicated result. 83% of students are familiar with certain design and drafting codes and standards and comply with their application.

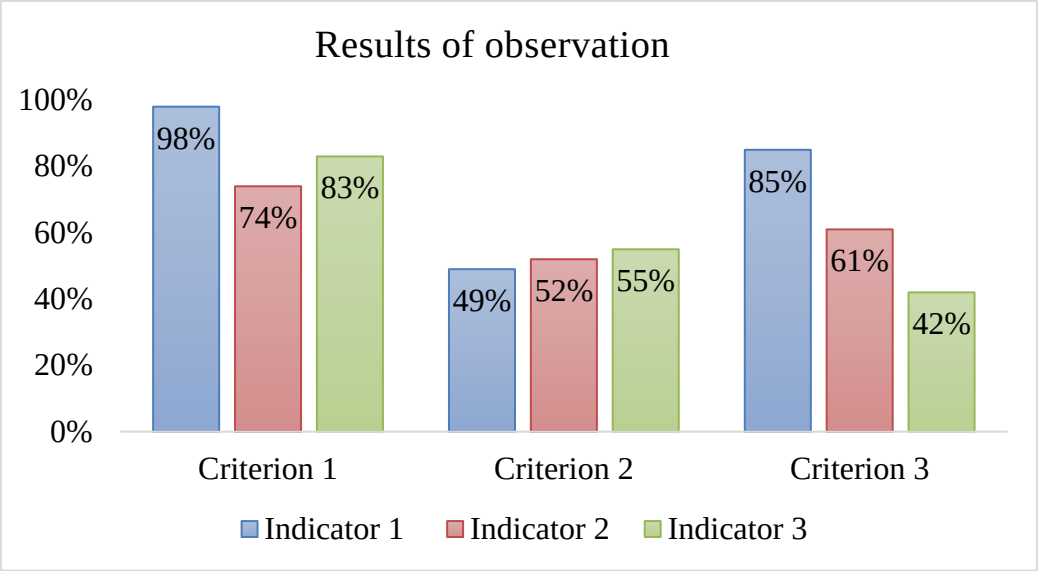


Figure 1

Regarding the second criterion „Creativity and design skills“, in all three indicators students show average results - 49% have the ability to design and create innovative and functional designs in AutoCAD. To add details, textures and colors that enhance the visual aspect of the designs 52% of the students can do it. And 55% of future engineers develop different options and alternative solutions for a given task. Presumably, these results are because students are in their first year and have not yet mastered all the details of AutoCAD application in a practical sense.

The third criterion „Collaboration, team communication when working with AutoCAD and project management“ is extremely important for today's engineering professionals and it is gratifying that 85% of the students communicate and interact effectively with their colleagues in the team where they work together with AutoCAD, and also exchange CAD files, coordinate with them the upcoming tasks they need to complete and clearly express their ideas and needs. Significantly fewer, 61% of learners, create and manage projects in AutoCAD as well as organize file structure and work with templates. And only 43% have the ability to track deadlines and manage their time effectively when working on projects in AutoCAD. According to the researchers, students' workload and the difficulty they have balancing their university studies, professional commitments, family obligations, and other commitments are the factors for the scores obtained on indicators 2 and 3 of the third criterion.

Results of discussion with teachers

The discussion held with lecturers from universities teaching future engineers to design, model and draw with AutoCAD included the following questions and their summary answers:

1. What difficulties do students encounter when working with AutoCAD?

Students may encounter various difficulties when working with AutoCAD, especially if they are beginners or do not have sufficient experience in using this software. The reasons for the typical difficulties experienced by students, according to the tutors, are:

Complex interface – AutoCAD has an extensive interface with many tools and options. New users can often be overwhelmed by the numerous menus and tools.

Complexity of commands and instructions – some commands and instructions in AutoCAD require precise knowledge and following certain steps, which appears as a challenge for beginners.

Spatial orientation – working with 2D models requires good spatial orientation, which not all students have and have difficulty creating accurate drawings and designs.

Lack of practical experience – students who do not have the opportunity to practice regularly forget certain techniques and need to start everything over.

Compatibility and file formats – compatibility issues and different file formats are a prerequisite for data loss or difficulties in exchanging projects.

Solving these difficulties takes time, systematic learning and practice. The right teaching style, methods, and specific resources will greatly help students overcome these challenges and become good AutoCAD professionals.

2. What psychological qualities and skills do students need to acquire professional competencies and be successful with AutoCAD?

Patience and persistence – AutoCAD training requires multiple experiences and practice before students achieve a high level of proficiency with the software. Patience and persistence are important as not everything will always come easily and quickly.

Problem thinking and creativity – the ability to analyze problems and create innovative solutions is key when working with AutoCAD. Students who are creative and can think outside the box often achieve better results.

Ability to analyse and think logically – AutoCAD requires logical thinking and analytical skills, especially when designing and solving complex problems.

Ability for self-regulation – students must organise their time effectively and work independently, especially on AutoCAD exercises and projects.

Ability to learn from mistakes – mistakes and failures are part of the learning process, which is a good opportunity for students to learn from them and make corrections.

Ability to work in a team – it is common for students to work on engineering projects in teams and it is critical that they have the ability to communicate and collaborate with others.

Ability to overcome stress – workloads and deadlines cause stress and it is important that students are able to deal with this stress constructively.

Ethical conduct – working in engineering and design requires responsibility and adherence to ethical standards that students must understand and apply.

Interest, motivation and self-motivation to improve in the engineering field – it is of utmost importance that students have an interest and motivation in the engineering field in order to fully engage in the learning process. In addition, AutoCAD training is characterized by intensity, therefore self-motivation is important for students to achieve good results.

These psychological qualities are important success factors in learning and working with AutoCAD. Combining technical and psychological aspects is key to developing competent engineering and design professionals.

3. What are the key challenges educators face when teaching students using AutoCAD?

Educators who teach AutoCAD and similar software tools may also face a number of challenges. Some of these are:

In-depth expertise – it is necessary that the teachers have a high level of knowledge and skills in the field of AutoCAD, be specialists with a wide experience in using the software and understand the details of the different versions and functionalities of AutoCAD. They must be able to solve complex problems and provide expert training and guidance to their students.

Update of training materials – the technology environment is evolving very rapidly, and educators need to constantly update their teaching materials to reflect the new capabilities of AutoCAD.

Individual approach to students – students often have different levels of knowledge, experience and skills. It is important that educators find ways to provide instruction and support tailored to the abilities and needs of each learner.

Specific tasks and projects – engineering and design education requires students to solve specific problems and create projects, which requires educators to formulate appropriate assignments with challenges for future engineers.

Preparing for work in industry – educators should not only teach students how to use AutoCAD, but also prepare them to work in a real engineering environment, including introducing them to standards and practices that are common in their fields.

Evaluation and feedback – assessing students and providing feedback on their progress is an important part of the educational process, which in turn is time consuming for teachers and requires careful evaluation.

Maintaining student motivation – Learning CAD software is a challenge that requires educators to find ways and means to keep student motivation high throughout the course of study.

Opportunities for professional development – educators should have professional development and continuing education opportunities to stay informed of the latest industry trends and practices.

Overcoming these challenges requires faculty flexibility, lifelong learning, and a commitment to the development of their students. Active communication with industry and colleagues would also help educators be successful in passing on their AutoCAD knowledge and skills.

CONCLUSION

This analysis paper examines the important role of psychological and social aspects in the education and training of students using AutoCAD. The paper highlights the following conclusions and implications:

- Engineering education and the use of AutoCAD requires a complex set of skills and to successfully meet the challenges in the learning process, students need to develop both technical and psychological and social skills.
- Psychological aspects are important for effective learning and working, respectively patience, creativity, problem solving ability and motivation are psychological qualities that assist students in learning and using AutoCAD.
- Social skills are also important, which is why the ability to collaborate, communicate and work in a team is integral to engineering practice and the use of AutoCAD.
- Appropriate assessment and feedback are essential, requiring lecturers to provide these to students to help them develop academically, psychologically and socially.
- Learning AutoCAD is a lifelong process, and technological advances require constant updating and refinement of students' skills as well as their psychological and social aspects.

In conclusion, the paper highlights the need for an integrated approach to AutoCAD training that incorporates technical, psychological and social aspects. Developing competitive engineers and designers requires combining these different factors to prepare competent professionals for the engineering industry.

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