INNOVATIONS IN WOODWORKING INDUSTRY AND ENGINEERING DESIGN

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Article

A PROJECT-BASED APPROACH TO CAD EDUCATION: A CASE STUDY AT THE UNIVERSITY OF FORESTRY

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ABSTRACT

Innovative approaches involve a critical rethinking of traditional methods and processes, incorporating novel ideas that necessitate new solutions to existing problems. They extend beyond technology to encompass business strategies, education, culture, and social initiatives. The implementation of innovation entails the integration of emerging technologies, new modes of thinking, and alternative forms of interaction, leading to improved outcomes and optimized processes. This study presents an original approach implemented within a module of the course "CAD Design Fundamentals", taught to students of "Computer Technologies in the Furniture Industry" program at the University of Forestry in Sofia. The approach aims to integrate technological and organizational innovations in higher education. Students are required to create a technical drawing using unfamiliar CAD software, integrate it into AutoCAD, and subsequently prepare a poster presenting the completed work. Preliminary implementation results are reported. The proposed approach is intended to enhance the digital professional competencies of engineering-oriented students.

Keywords: *information technologies; innovation; approach; CAD training; higher education*

INTRODUCTION

Innovation – encompassing activities, processes, and behaviors that enhance services, products, systems, and technologies – is becoming an increasing priority across multiple domains. In education, the need to adopt innovative practices is particularly pronounced, as they diversify traditional teaching approaches, improve pedagogical effectiveness, and foster greater learner engagement. Concepts such as innovation, innovative school and classroom, innovative approaches, and innovative skills are introduced to strengthen learners' knowledge, skills, and competencies.

A distinction should be made between innovation and innovativeness [1]. Innovation denotes the introduction of something new, whereas innovativeness refers to the capacity to implement and apply innovations.

Based on a review of selected educational innovations and practices in Europe and Bulgaria, a project-based approach was developed and implemented within a module of the course

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"CAD Design Fundamentals" for students of "Computer Technologies in the Furniture Industry" program at the University of Forestry (UF). The approach aims to enhance students' digital professional competencies. Results from a three-year implementation period are reported, with outcomes analyzed against curriculum requirements and student expectations.

1. EUROPEAN SUPPORT FOR INNOVATION

The European Institute of Innovation and Technology (EIT) [2] was established in 2008 with the mission of promoting sustainable economic growth and competitiveness by strengthening the innovation capacity of the Union and its Member States [3]. The aim is to integrate higher education with research and innovation, through the development of knowledge and innovation communities. Approaches to students and higher education should be innovative and entrepreneurial. To achieve these objectives, it is necessary to strengthen the following activities:

[1] exchange and implementation of best practices in upskilling and reskilling, professional guidance and mentoring;

[2] development of action plans in response to needs in areas such as innovation creation and management, technology transfer, intellectual property rights management, sustainability and climate neutrality by design, etc.

Scientix [4], developed by European Schoolnet [5], is a leading European initiative in science education. It provides a platform for sharing and co-creating resources and services to enhance STEM (Science, Technology, Engineering and Mathematics) education, linking it to global challenges, expand access to STEM careers, and support collaboration and mutual learning among educators.

The European Innovation Scoreboard provides a framework for measuring the research and innovation performance of the European Union (EU) Member States, based on 32 indicators. It draws on 2018-2025 data to assess and benchmark performance [6]. The report finds that Europe's innovation performance remains strong, though growth is slowing. In 2025, four countries comprised the group of leading innovators with results exceeding 125% of the EU average, led by Sweden. Bulgaria is classified among emerging innovators with an innovation index of 45.8%, down 2.2% from 2024 [7]. This result places Bulgaria below 70% of the EU average.

2. INNOVATION IN BULGARIAN EDUCATION

According to Iliev [8], pedagogical innovation is a change in the content and technology of education, improving the quality of education and the education system. This can be achieved

by introducing innovative forms of learning, such as incident learning; problem-based learning; game-based learning; project-based learning; experiential learning, etc.

Two models can be defined within this approach to the educational process [9]:

- technological learning models – aim to achieve predefined outcomes through monitoring and adjustment. The teacher acts as an operator of instructional tools, while the student is treated as an object of instruction with predefined goals.
- research-oriented models – focus on learners who independently construct knowledge through research, play, modeling, discussion, and exchange of ideas. Here, the learner takes an active role, and the teacher serves as a facilitator in expanding and deepening students' experience.

Totseva defines innovation as a "purposeful, planned, and controlled change that solves organizational and substantive problems across various fields of human activity" [10].

By scope, innovations are technological, product, market, and organizational and managerial, and occur not only in economics but also in education [11]. They can also be classified by degree and nature of change, reasons for implementation, and chosen strategy.

Naydenova [12] classifies educational innovations according to:

- educational level – preschool, primary, elementary school, etc.;
- main focus – changes in material environment, participants in the process, teaching tools;
- scope – school, university, local, regional, etc.;
- area of change – content and learning process, skill formation, teacher qualification;
- purpose – innovations addressing educational needs and solving teaching and learning problems.

Under the National Recovery and Resilience Plan, component "Innovative Bulgaria", a network of nine research universities was established by the end of 2022 [13]. The universities receive funding to develop high-quality research and foster academia–business partnerships, each implementing a four-year strategic program for research and innovation [14].

Regardless of field, model, duration, or context, innovation should enhance learning quality and individuals' intellectual capacity. A study by Boyadzhieva and Velikova [15] shows that Bulgarian teachers view innovative methods positively: 42% use them daily, 31% weekly, and 17% in every lesson. While their benefits are evident, effective implementation depends on the competencies of teachers and staff, as well as on policies, conditions, and technologies.

School innovation goes beyond STEM classrooms to include new teaching approaches, subjects, organization, content, digitalization, and interdisciplinary learning. This redefines the teacher's role – from a source of information to motivator, coordinator, and facilitator [16].

Collaborative learning is central: students work in teams to solve problems, apply knowledge, present results, and assess one another. This requires a tolerant, supportive teaching approach that fosters focus, independence, and teamwork [17].

Research on innovations in IT-related engineering education remains limited. Manolov et al. [18] apply a project-based interdisciplinary approach in "Microtechnologies and Nanoengineering" to improve graduate preparation, while Dimitrova [19] proposes a digitalized model at the University of Ruse, replacing paper-based materials.

According to the World Economic Forum [20], key skills by 2025 include active learning, analytical and critical thinking, creativity, complex problem solving, communication, and teamwork.

As noted by Stoichkova and Dimitrova [21], educational innovation is a process based on the implementation of research findings. The authors emphasize that ineffective governance and insufficient funding hinder the development of a sustainable innovation policy in higher education, thereby limiting opportunities for long-term strategic development. Georgiev and Velushev [22] indicate that higher education strategies should be guided by the innovation model and foster conditions that address the mismatch between the societal division of labor and the development of workforce competencies.

The Strategy for the Development of Higher Education in Bulgaria for 2021–2030 [23] identifies several key challenges within the current educational model related to digitalization, innovation in teaching, and the competency-based approach. In general, the objective of digital education is to provide young people with opportunities to express and implement ideas and projects through the use of modern information technologies and methods. However, the existing education system does not adequately support the practical development of the necessary digital and life skills, including personal, social, and entrepreneurial competencies. Furthermore, the digital transformation of production and service technologies is not aligned with educational reform, limiting learners' ability to successfully transition to new professional and social roles.

The Higher Education Development Strategy proposes a range of activities and measures aimed at achieving its objectives for the introduction of modern, flexible, and effective forms of learning, including:

- strengthening the role of students' independent and creative activities through the preparation and presentation of critical analyses of specific issues, the solution of practical tasks, participation in research activities, and other forms of active engagement.
- assessing students' knowledge and skills not on the basis of memorized information, but through their ability to engage in debate, conduct scientific experiments or theoretical modeling, solve real-world problems, demonstrate digital creativity, and effectively use a variety of digital tools to accomplish tasks in authentic professional and social contexts.

As a result of these activities and measures, a high proportion of graduating students is expected to demonstrate well-developed abstract, associative, and creative thinking, as confirmed by their employers, while the university digital environment is expected to provide continuous intellectual stimulation.

Despite the identified challenges, measures, and activities outlined in the Strategy, there is no clearly defined methodology specifying how teaching should be implemented in accordance with the specific characteristics of each professional field in order to achieve the stated objectives of flexible and effective forms of learning, innovation, and the competency-based approach. Moreover, no unified approach has been developed and applied at the level of institutional organization – university, faculty, or department – which underpins the project-based approach proposed in this study.

3 METHODOLOGY OF A PROJECT-BASED APPROACH IN CAD SYSTEMS TRAINING

3.1 Characteristics of the target group

The approach was applied to bachelor's students enrolled in "Computer Technologies in the Furniture Industry" at the UF, within professional field 5.13 "General Engineering". The program prepares engineers with competencies in digitalization, digitization, and CNC processes, awarding the qualification "Computer Technologies Engineer in the Furniture Industry" [24-25]. Graduates are expected to apply modern digital tools for design and modeling, solve non-standard problems creatively, work effectively in teams, and transfer their knowledge to new and interdisciplinary contexts.

3.2 Purpose of the approach

The proposed approach aims to develop and support the specific digital competencies and skills relevant to the future profession.

The main goal of the proposed project-based approach is to enhance students' digital professional competencies by introducing and working with new software in an unfamiliar and unanticipated setting.

FreeCAD [26] was selected as the unfamiliar software because it is:

- free and open-source;
- installable without administrator rights in the university computer lab;
- compatible with AutoCAD [27];
- offers parametric modelling capabilities.

Additional objectives include:

- restructuring the traditional class format focused on predefined drawing tasks;
- promoting teamwork and adaptability;
- fostering creative thinking during the learning process.

3.3 Tasks

To achieve the objectives, students are required to:

- install FreeCAD (version 1.1) [26];
- create a complex 3D model consisting of 2–3 elements in FreeCAD, without predefined dimensions or parameters (creative design task);
- export the file in a format compatible with AutoCAD 2024 [27];
- import the model into AutoCAD and integrate it into an existing 3D furniture design;
- select and apply appropriate materials and textures from the AutoCAD library;
- create a project poster using Canva [28], presenting all stages and author names in a creative layout;
- complete a short three-question online survey at the end of the session to assess satisfaction with the project-based approach.

To support successful completion of the assigned tasks and implementation of the project-based approach, the instructor assumes the role of a mentor, supporting and guiding students in their work with unfamiliar software without directly providing ready-made solutions. This encourages students to engage in independent learning, problem-solving, and the active construction of new knowledge and skills.

3.4 Stages of implementation

The project-based approach was implemented for first-year students in the course "CAD Design Fundamentals," which is taught over two semesters with a total of 75 hours of practical classes.

The approach was first applied to nine students during a two-academic-hour practical session in the summer semester of the 2023/2024 academic year. The students were divided into three groups, and a leader was assigned to each group. Each group leader distributed the tasks, prepared and formatted the poster, and emailed it to the instructor. Each student independently completed an online questionnaire.

To monitor development and validate the results over time, the same project-based approach (with identical tasks and questionnaire items) was also applied in the 2024/2025 (7 students) and 2025/2026 (6 students) academic years to first-year students in the "Computer Technologies in the Furniture Industry" program. Figure 1 shows some of the completed student posters from the two academic years.

Figure 1. Student posters created in Canva during the 2023/2024 and 2025/2026 academic years

The results of all questionnaire responses are summarized and presented in the following section.

4 DISCUSSION AND RESULTS OF THE STUDENT SURVEY

Students from all three cohorts participated actively and successfully completed the assigned tasks. In response to the question "Did you experience difficulties while working with the new applications?", 60% answered "No difficulties", the distribution across the three academic years being shown (Fig. 2).

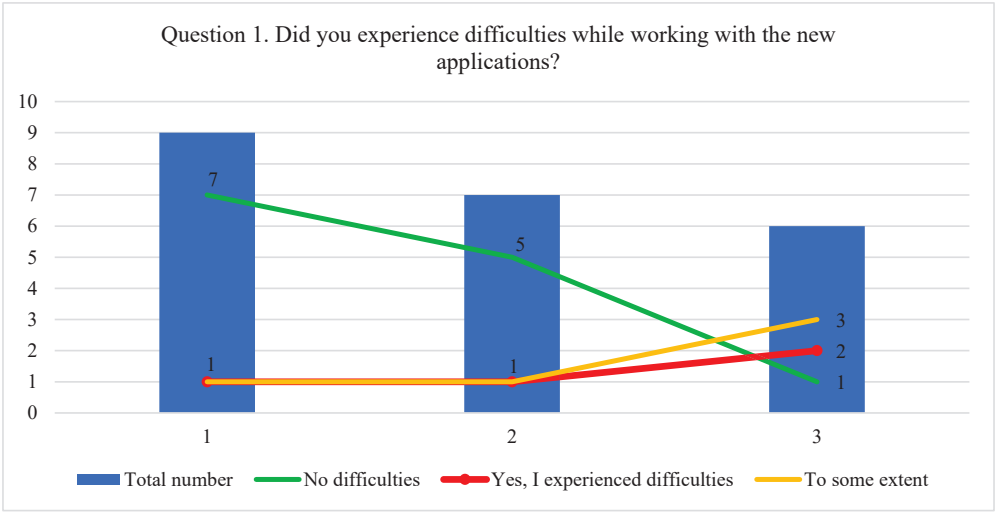

Figure 2. Distribution of answers to Question 1 across the academic years

Notably, the responses from the 2025/2026 academic year differ from those in previous years. The results show an increase in students reporting definite or some difficulties (a total of 5 students), while only 1 reported no difficulties. This may be due to differences in prior IT preparation in secondary education or a more critical attitude towards working with FreeCAD.

For Question 2, students were asked to rate, on a scale from 1 to 5, the extent to which the approach enhanced their digital professional competencies. Among respondents, 55% gave a rating of Very High (5), indicating that their assessment is above the midpoint (Fig. 3).

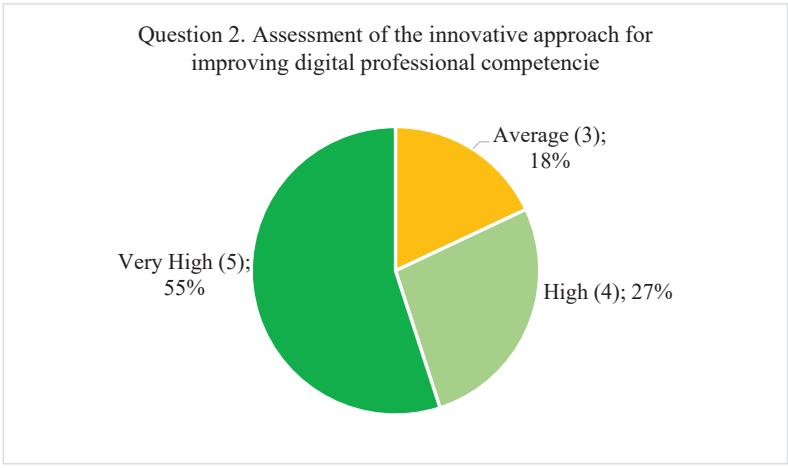

Figure 3. Answers to Question 2

The findings indicate a high level of student satisfaction with the applied approach and its contribution to the enhancement of digital professional competencies. The predominance of

the highest rating demonstrates that students recognize the practical value of the approach in preparing them for digitally oriented professional environments.

Among the surveyed students, 82% expressed a desire for innovative approaches to be applied in other courses as well (Fig. 4), and none responded "No". Students from the 2025/2026 academic year who selected "cannot assess" are slightly more numerous compared to previous academic classes (Fig. 5).

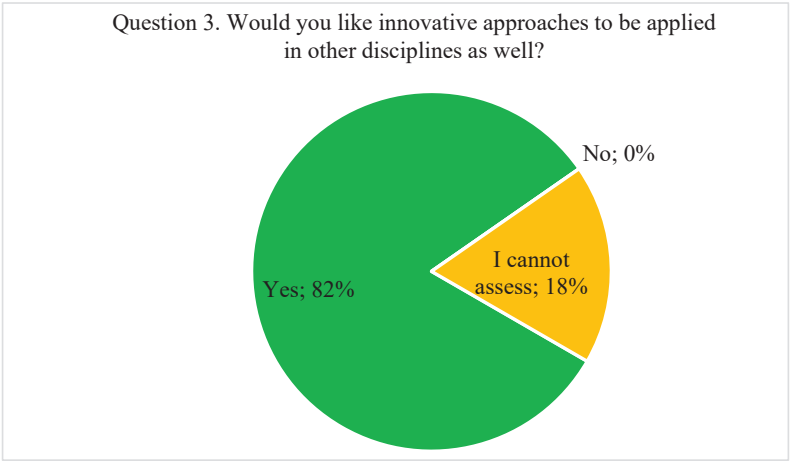

Figure 4. Answers to Question 3

The high percentage of positive responses indicates students' willingness to engage with contemporary educational practices and supports the continued implementation of innovative pedagogical strategies. The slightly higher proportion of students who were unable to assess the approach may reflect their limited exposure to such methods or the need for additional experience before forming a definitive opinion.

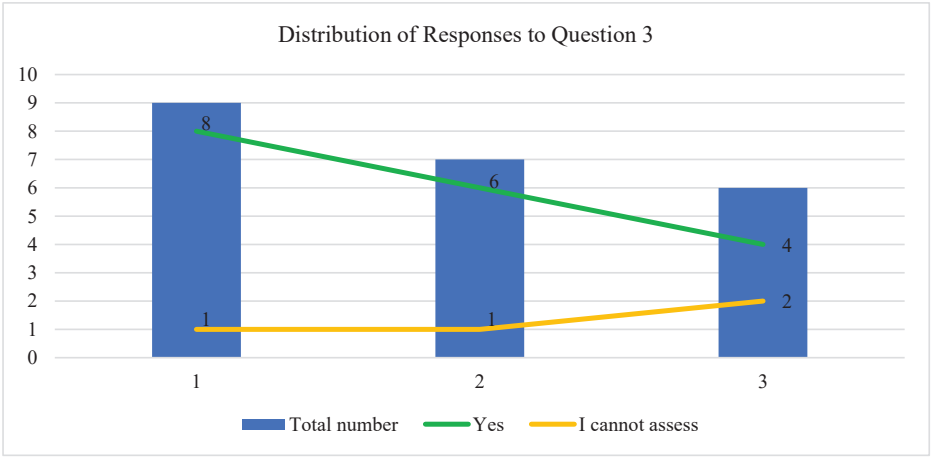

Figure 5. Distribution of answers to Question 3 across the academic years

Overall, working with FreeCAD did not pose major difficulties for students; however, its interface is not intuitive, and commands are executed differently than in AutoCAD. In particular, element selection follows a different workflow, dimensioning is more complex, and the tool palettes are less straightforward. Despite these software limitations, the main learning objectives were achieved.

The additional objectives were not fully realized to the intended extent. Creative thinking was most effectively demonstrated in modeling the complex figure in FreeCAD. In contrast, creativity in poster design using Canva showed certain limitations, possibly due to fatigue, time constraints, a preference for minimalistic design, or similar factors. Teamwork was generally successful, with only minor exceptions likely caused by external factors not discussed here.

The first stage of the study demonstrated the successful implementation of an innovative teaching approach in the course "CAD Design Fundamentals" within the "Computer Technologies in the Furniture Industry" program, aimed at enhancing students' digital and professional competencies at the UF. The project-based approach will continue to be applied in future academic years using different software solutions, with results to be further analyzed and compared.

These results suggest that this method creates a suitable environment for educational innovation in this and other university programs. The developed approach, developed through this educational experiment, can be further extended and adapted, serving as a model for similar implementations in other university courses.

The main objective of the proposed project-based learning approach in "CAD Design Fundamentals" was successfully achieved. The approach is also directly aligned with the learning outcomes defined in the curriculum of the "Computer Technologies in the Furniture Industry" programme.

CONCLUSIONS

Innovation is a key driver of progress in education. This is particularly relevant to programmes such as "Computer Technologies in the Furniture Industry" at the University of Forestry, where technological change is inherent to the field and the development of an innovative mindset is an important component of professional preparation. Innovative approaches can create added value and support sustainable educational development.

In the longer term, continued work on such projects may help create an educational environment in which project-based approaches, technologies, and practices become an established framework for educational development.

ABBREVIATIONS

The manuscript contains the following abbreviations:

UF	University of Forestry
CAD	Computer-Aided Design
STEM	Science, Technology, Engineering and Mathematics
EU	European Union
EIT	European Institute of Innovation and Technology
CNC	Computer Numerical Control
IT	Information Technologies

AUTHOR CONTRIBUTIONS

Conceptualization, A.I. and M.N.; methodology, A.I. and M.N.; formal analysis, A.I. and M.N.; investigation, A.I. and M.N.; resources, A.I. and M.N.; data curation, A.I. and M.N.; writing—original draft preparation, A.I. and M.N.; writing—review and editing, A.I. and M.N.; visualization, A.I. and M.N.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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CONTENTS

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