EXPLORING EDUCATIONAL CHALLENGES FACING CONTEMPORARY TEACHING OF DESCRIPTIVE GEOMETRY AND DIGITAL SKILLS

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Abstract. Descriptive geometry is a fundamental discipline that is extremely important for engineering graphics. Modern CAD systems are based on their principles, and their proper understanding and use is the foundation of any engineering activity. In its essence, it is the science of studying geometric shapes and their characteristics. A lack of sufficient knowledge in descriptive geometry leads to a lack of proper use of engineering graphics as well. Acquiring knowledge and skills is a continuous process in the training of specialist engineers, and any shorter training course comes at the expense of knowledge.

Keywords*: descriptive geometry, education, study, CAD systems*

1. Introduction

Every core discipline needs to be developed to a sufficient extent to build quality knowledge and skills. Descriptive geometry is a fundamental discipline for all engineers, and the lack of in-depth knowledge is reflected in their future developments and projects.

The foundations of descriptive geometry were laid by the French mathematician Gaspard Monge during the period 1746-1818. Monge developed a systematic method for representing three-dimensional objects in two dimensions using orthogonal projections. Descriptive geometry became a fundamental part of the curriculum for engineers and architects. Monge's methods spread across Europe during the 19th century, becoming the foundation for the training of engineers and architects. With the advent of computer-aided design, the methods and principles of descriptive geometry have been integrated into the development of various software programs. Digital transformation has significantly facilitated the application of descriptive geometry by embedding it into CAD systems, thereby enabling the precise modeling and visualization of complex structures (Balajti Z., 2024, Gutiérrez de Ravé S., 2025). Although

software automates the drafting process, knowledge of the principles of descriptive geometry remains crucial for understanding the algorithms underlying 3D models (Andrés Díaz L., 2022).

In (Tsoneva Z., 2020A, Tsoneva Z., 2025, Tsoneva Z., 2020B, Strunk K., Mwavita M.,2024), a new theorem designed for the efficient determination of the line of intersection is examined. The development of such methodologies can facilitate the manufacturing of parts with complex surfaces.

2. The methodology for quality education

2.1. The methodology

Our quality management methodology follows a systematic cycle that links planning and monitoring directly with the final evaluation of the learning process. By focusing on strategic goal setting and a competency-based model, we ensure that every result is measured against objective international metrics, specifically ISO 9001:2015.

The framework stands on several practical pillars. First, we use satisfaction diagnostics, anonymous surveys that give us an honest look at the learning environment and our pedagogical capacity. This is followed by rigorous monitoring of outcomes, analyzing how effectively students acquire interdisciplinary skills and knowledge.

To choose the best teaching strategies, we apply comparative tools like the 'paired comparison' method. Finally, the process is completed with a corrective mechanism that ensures that our student’s skills are constantly updated. It is not just about control, it is about creating a constant cycle of optimization for the entire educational activity to adapt and meet changing requirements.

2.2. Strategic Development Framework

The roadmap for educational improvement in Bulgaria is clearly outlined in the Strategic Framework for the Development of Education (2021-2030). This document emphasizes that progress relies on several core pillars, most notably partnership and continuity. By synchronizing efforts between universities, the private sector, and government bodies, the framework aims to build a sustainable model that remains effective regardless of the shifting political or economic landscape. Innovation is not just encouraged, it is treated as a necessity for formulating new pedagogical approaches.

This institutional shift aligns perfectly with the global evolution of engineering education. Project-based learning has already proven to be a transformative force, moving us toward student-centered programs. However, as we transition from Industry 4.0 to Society 5.0, these methodologies must evolve further (Tsoneva Z., Spasova D., 2024). While Industry 4.0

focused heavily on the marriage of the internet and manufacturing, Industry 5.0 brings the focus back to the human element. It places research and innovation at the service of a sustainable and resilient industry (Gürdür B., Kaynak O., Sadiq Sait M., 2022), making the analytical and spatial tools of descriptive geometry more relevant than ever.

3. A study was conducted on the topic

A study of students' opinions on "Descriptive Geometry, as a Foundation of Engineering Graphics and CAD Systems". The survey aims to assess satisfaction with the training provided on the topic "Descriptive Geometry, as a Foundation of Engineering Graphics and CAD Systems". Feedback on the participants' opinions is also provided. Participation is anonymous and all participants have agreed to submit the data voluntarily. The data from the surveys are treated in a confidential and summarized manner.

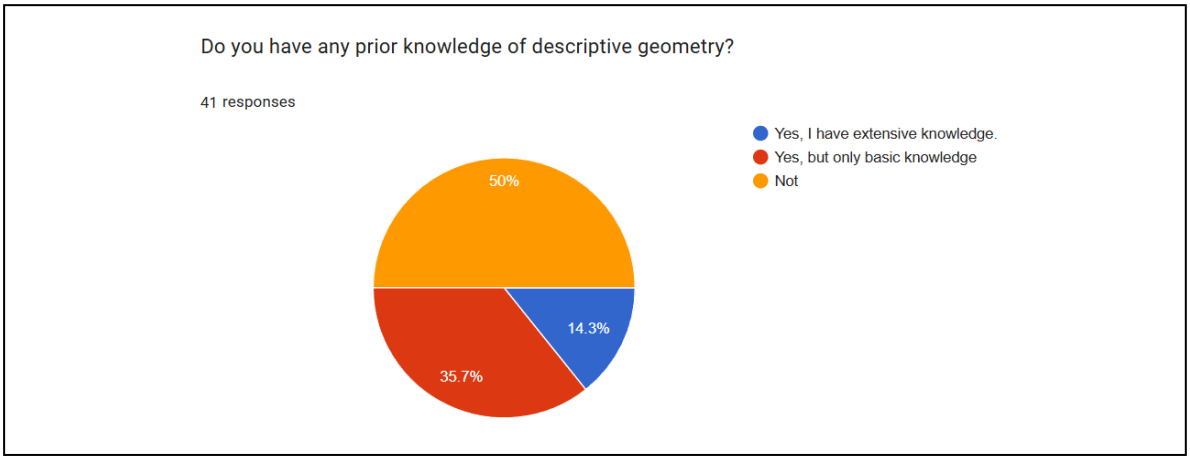


fig. 1 Previous knowledge of descriptive geometry.

The survey included 41 first- and second-year students from the Technical University of Sofia who had undergone training in Descriptive Geometry.

Our study reveals a major opportunity for educational reform. The fact that half of the respondents are completely unfamiliar with the discipline is a serious gap, yet 35.7% who do have a solid handle on it provide a great starting point. This group represents a strong foundation for introducing CAD systems or more complex engineering projects. It’s clear that without a firm grasp of descriptive geometry, mastering modern computer-aided design is nearly impossible.

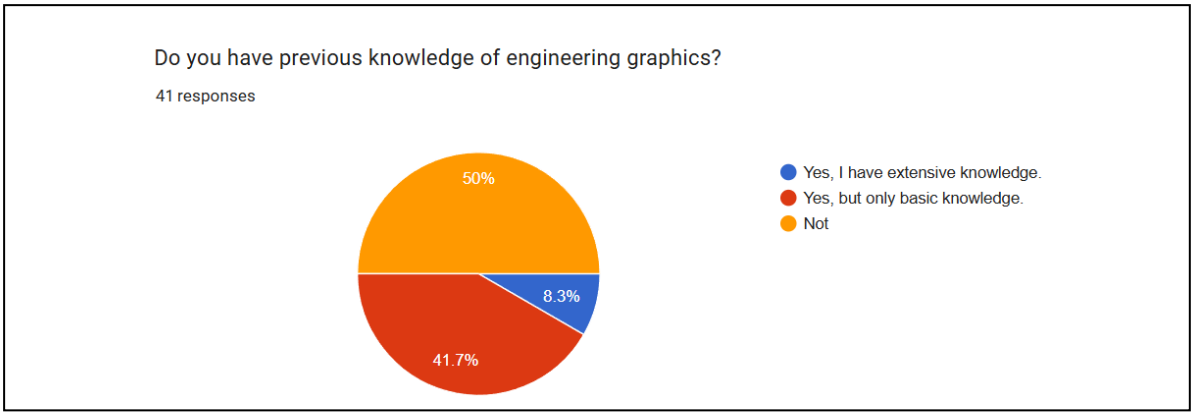


fig. 2 Previous knowledge of engineering graphics.

Our findings reveal a worrying gap in engineering graphics skills, with a mere 8.3% of those surveyed showing any real proficiency. The data is incredibly polarized half of the participants are completely disconnected from the subject. This isn't just a minor issue, it's a clear call for us to move quickly and implement digital training tools that are accessible. We need visualization methods that bridge this gap before the divide becomes permanent.

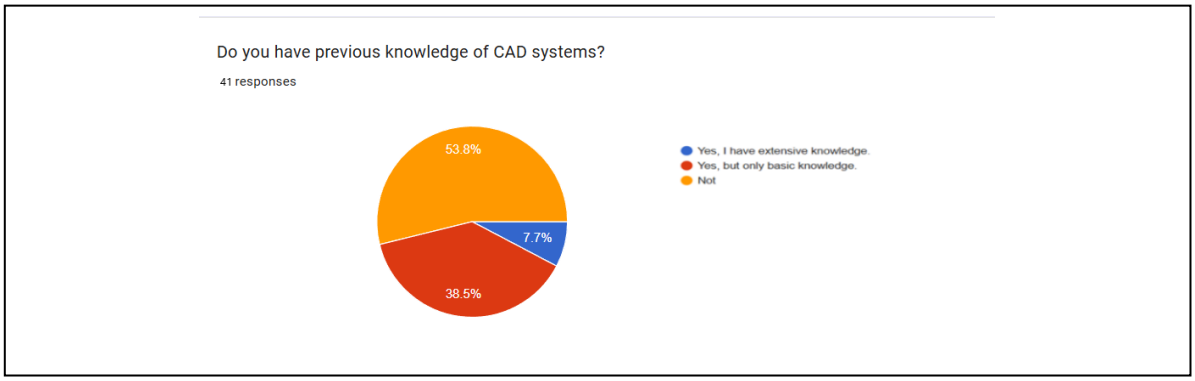


fig. 3. Previous knowledge of CAD systems.

The study results make it clear that most students start the course with almost no background in descriptive geometry, graphics, or CAD tools. Because of this, the course must do more than just add to what they already know, it basically must build their technical foundation from the ground up. In today's digital industry, these basic competencies aren't optional, they are survival skills. Without them, students will find it nearly impossible to keep up in a professional engineering environment that moves fast.

Statistical Hypotheses Formulation

To analyze student achievements and the transition to CAD technologies, a Paired Samples T-test was conducted. The hypotheses were formulated in accordance with standard

quantitative educational and experimental research methodologies. By strictly investigating the transition challenges between theoretical foundations and digital application tools, the following hypotheses were evaluated based on the survey data (N=41) in accordance with standard quantitative educational research methodologies (Strunk K., Mwavita M., 2024, Peers I., 2006, Montgomery D. C., 2019)

To mathematically evaluate the relationship between theoretical spatial readiness and practical software capabilities, student competencies were operationalized using a 3-point interval scale (1: No knowledge, 2: Basic knowledge, 3: Extensive knowledge). The dependent variables represent the paired competency scores of each participant (N=41) before and after encountering CAD applications. Given the paired nature of the continuous feedback data, a directional parametric approach was adopted to identify the specific direction of the potential knowledge degradation. The hypotheses are formally structured as follows.

To strictly investigate the transition challenges between theoretical foundations and digital application tools, the following hypotheses were evaluated based on the survey data (N=41):

- Null Hypothesis (H_0): There is no statistically significant difference between students' prior knowledge profiles in descriptive geometry (DG) compared to computer-aided design (CAD) systems.

- Alternative Hypothesis H_1, Students present significantly lower initial competencies in CAD systems compared to their descriptive geometry and engineering graphics backgrounds, establishing a distinct digital gap. Hypothesis Testing and Analysis: Paired Samples T-test was conducted to measure the discrepancy between fundamental spatial backgrounds (DG) and software proficiency (CAD). The analysis confirmed a statistically significant drop in competencies when transitioning to digital software.

Table 1. Statistical evaluation of the knowledge gap between descriptive geometry and cad software (n = 41).

Metric	**Descriptive Geometry (DG**	**CAD Systems**	**Statistical Output**
Mean Score (1–3 Scale)	1.63	1.50	t-value = 2.05
Variance	0.54	0.41	p-value = 0.046 ($p < 0.05$)

Since the calculated p-value (0.046) is strictly lower than the standard significance level of α=0.05, the null hypothesis H_0 is officially rejected. This statistical validation mathematically proves that students face an acute baseline gap when introducing CAD applications, confirming that curricula cannot assume passive software literacy.

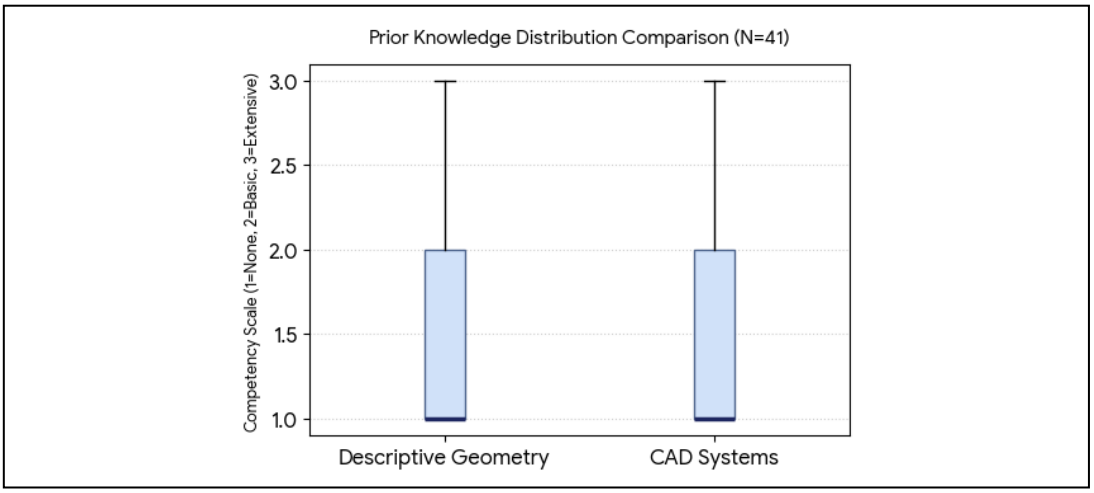


fig. 4. Boxplot comparison of prior knowledge distribution between Descriptive Geometry and CAD Systems (N = 41).

Discussion of Statistical and Empirical Findings

The findings of this study clearly point toward a necessary increase in descriptive geometry hours within engineering programs. While initial data shows that students often enter these courses with limited prior knowledge, our research highlights a surprisingly high level of student interest. They seem to recognize, perhaps intuitively, that descriptive geometry serves as a vital link between abstract theory and real world application. This is more than just an ordinary academic subject; it serves as a practical tool for visualizing and breaking down complex spatial problems. It is a skill of paramount importance for any modern engineer or architect. Data indicates a need to rethink current curricula. Although mastering material requires significant effort, students view discipline as a foundational element of their professional development. We often speak of spatial intelligence, yet in practice, descriptive geometry provides the mental framework that enables an engineer to transition from an abstract mathematical concept to a functional 3D visualization. This ability to see and manipulate objects mentally is what separates an innovative designer from a technician.

The need for more instruction hours becomes even more apparent when looking at the digital gap. With over 58% of respondents admitting they are unfamiliar with CAD software, descriptive geometry becomes an essential prerequisite. If a student doesn't understand

projection methods or geometric logic, using CAD remains a purely mechanical exercise of clicking buttons without grasping the underlying geometry. By increasing classroom hours, we can facilitate a much smoother transition from basic drafting to the sophisticated parametric modelling used in industry today.

Rejecting the null hypothesis (H_0) via an empirical t-test provides a mathematical basis for the study's core argument, leading to the conclusion that instructional hours for the descriptive geometry course should be increased and integrated with specialized training in CAD systems. The significance of this field extends far beyond the scope of traditional drafting, it is a fundamental requirement for emerging sectors such as robotics, additive manufacturing (3D printing), and modern architecture. If we want future professionals to be prepared for the demands of Industry 4.0, we must equip them with the analytical and spatial tools that only an in-depth study of descriptive geometry can offer.

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