

Improving the Methodology for Preparing Future Engineers for Project Based and Engineering Activities

Uzokov Sherzod Xamidovich

Independent researcher at Samarkand State Pedagogical Institute, Uzbekistan

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Abstract: This article outlines the methodology for preparing future engineers for project based and engineering activities based on a competency-based approach. It analyzes the didactic potential of utilizing project-based learning, adaptive learning platforms, brainstorming, and digital design tools in teaching descriptive geometry and engineering graphics.

Keywords: Competency-based approach, future engineer, design and engineering activity, descriptive geometry, Project-Based Learning, adaptive learning.

Introduction: In today's engineering education system, assessing students' readiness for practical work and fostering their skills in design, construction, creativity, and engineering problem-solving remain key pedagogical priorities. Consequently, developing a comprehensive theoretical framework for teaching construction-related disciplines—specifically technical drawing and descriptive geometry—using modern instructional approaches is a crucial aspect of contemporary education [1].

Recent developments in higher education for construction have shifted the didactic focus toward a competency-based model. This approach prioritizes the cultivation of practical competencies over the mere transmission of theoretical knowledge. Therefore, a methodological system is required for teaching geometry that encourages independent thinking and enables students to analyze and formulate engineering solutions and design decisions [1].

The competency-based approach is an educational strategy that directs the learning process toward the practical application of knowledge rather than rote memorization. This approach focuses primarily on the student's readiness for professional practice—specifically, the complex quality formed through the

chain of "knowledge – skill – proficiency – competence" [2].

The research methodology was grounded in competency-based and activity-oriented approaches. The article employed methods such as theoretical analysis, pedagogical modeling, comparative analysis, the development of project-based assignments, and criterion-based assessment of learning outcomes. Methodological solutions were tailored to the content of Descriptive Geometry and Engineering Graphics, and the potential of PBL, adaptive learning platforms, brainstorming, and digital modeling tools to develop design and engineering competencies was analyzed [3].

Innovative methods such as Project-Based Learning, adaptive learning platforms, brainstorming, and generative design are being introduced into the educational process. Each plays a vital role in developing adaptive design competencies in future engineers. Through these methods, students act not merely as learners but as project authors, analysts, and designers. Project-Based Learning (PBL) is a modern pedagogical approach centered on students conducting independent research, organizing project activities, solving real-world problems, and creating a final product [4].

As a result of the developed methodological model, design and engineering activities were structured into sequential stages, ranging from problem identification to project defense and reflection. The content of PBL-based practical sessions, procedures for small-group work, and assessment criteria for ongoing, interim, and final evaluations were established.

Regarding adaptive learning platforms, functional modules—such as diagnostics, 3D visualization, automated analysis, adaptive tasks, progress monitoring, and gamification—were identified as tools to support the student's individual learning trajectory [4].

Lesson Topic: Constructing the line of intersection between a cylinder/cone and a plane

Type of lesson: Practical;

Duration: 2 hours;

Small group composition: 5–6 students;

Educational objective (developmental): To foster design and engineering skills in students;

Educational objective (instructional): To develop students' ability to conduct independent research, organize design activities, solve real-world problems, and devise solutions based on their knowledge and skills;

Expected outcomes: Development of students' design and engineering capabilities.

For the "Engineering Graphics" course, it is recommended to assess and grade students through the completion of the following tasks during current, interim, and final assessments (Table 1):

Table 1

Criteria for evaluating students' work results

No	Forms of independent work	Submission deadline	Assessment criteria
1. Tasks to be assessed during ongoing monitoring:			
1.	The student's active participation in lectures and the regular execution of drawings.	Till midterms Till finals	Up to 8 pts Up to 5 pts
2.	Preparing case studies on specific topics	Till midterms	Up to 5 pts
3.	Preparing PPTs on specific topics	Till midterms	Up to 6 pts
4.	Mastering all lectures delivered on the subject	Till finals	Up to 6 pts
2. Tasks to be assessed during midterms:			
1.	Preparing and presenting a presentation in small groups on approved topics.	Till finals	Up to 20 pts
3. Tasks assessed during finals:			
1.	Completing case studies, essays, control assignments, or other forms of independent work.	During the last two weeks of the semester	Up to 50 pts

Organizing the assessment of students' independent work—through ongoing, interim, and final evaluations—plays a crucial role in fully covering the study hours allocated to independent learning in the course syllabus and curriculum; it also fosters independent thinking, scientific-creative inquiry, and independent decision-making, while helping to develop the professional skills defined in the educational field and qualification requirements [5].

Analysis shows that integrating the competency-based approach with project-based and adaptive learning actively supports a student's independent thinking, spatial imagination, and constructive decision-making—unlike traditional instruction based on standardized assignments. In this context, while Project-Based Learning (PBL) focuses on addressing real-world problems and creating a final product, adaptive platforms allow task complexity to be tailored

to the student's knowledge level and pace of learning [6].

Adaptive Learning Platforms method. Each student possesses a different level of knowledge, set of interests, and learning pace. Consequently, traditional educational methods do not yield the same level of effectiveness for all students. AI-based adaptive learning platforms address this issue by providing each student with assignments tailored to their specific capabilities and pace. In engineering education, this method fosters the development of individualized design competencies [5, 7].

The core concept of the method is the principle of "instruction tailored to each individual student, rather than a 'one-size-fits-all' approach."

Adaptive Learning Platforms represent a didactic approach that creates an individualized learning path for each student by utilizing artificial intelligence algorithms, digital learning analytics, and the monitoring of student activity. During the educational

process, adaptive platforms (such as ALEKS, Smart Sparrow, Knewton, etc.):

- assess students' knowledge levels in real time;
- analyze their errors;
- offer assignments with complexity levels tailored to the individual;

Constructive competencies are developed, preparing students for independent design work.

Motivation increases through the use of game elements, rankings, and progress indicators.

This method fully aligns with the didactic requirements of modern engineering education and trends in digital transformation.

Overall, AI-based adaptive platforms enable the training of future engineers tailored to their individual abilities. They serve as a vital tool for developing competencies in independent decision-making, adaptive design, and rapid problem-solving [7, 8].

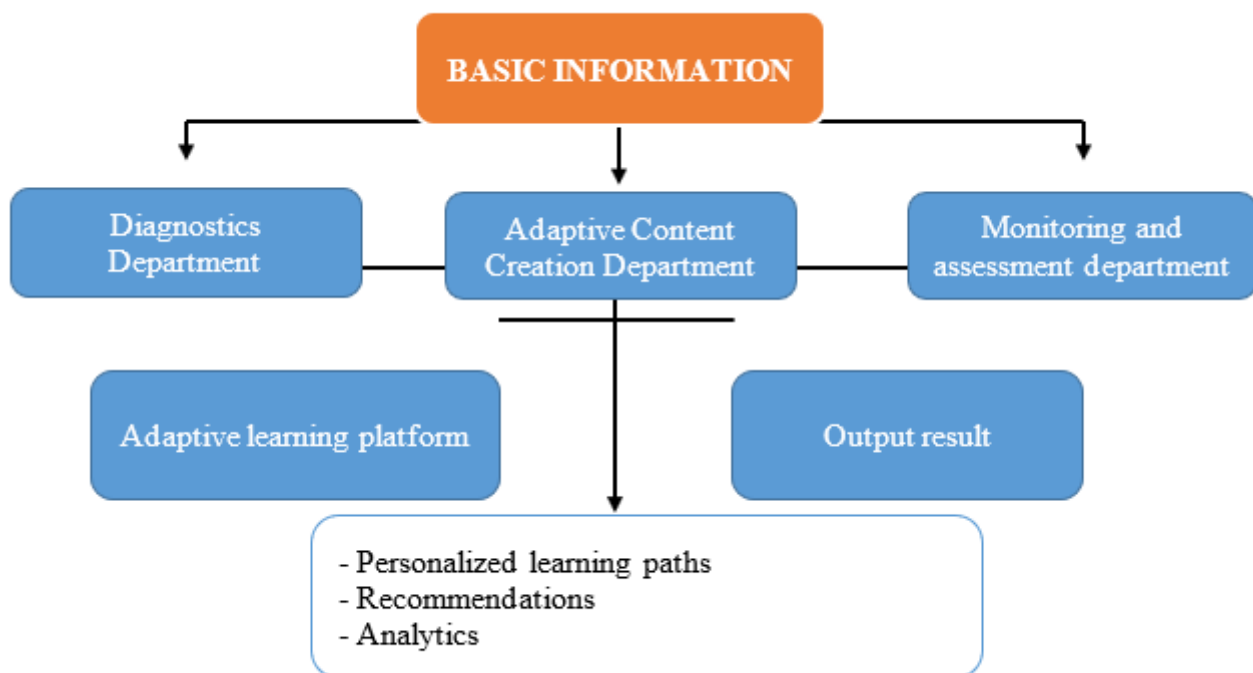


Figure 1. Adaptive Learning Platforms method

The application of this method in descriptive geometry education yields the following scientifically grounded results (based on international studies):

- A 25–40% increase in students' spatial-analytical thinking;

- Increased speed in solving complex projection problems;

- A sharp reduction in the number of errors;

- Enhanced readiness for independent constructive activity.

Adaptive learning platforms in descriptive geometry education:

- Develop constructive competencies;
- Strengthen spatial visualization and 3D thinking;
- Ensure an individualized approach;
- Make the teaching process scientifically grounded, goal-oriented, and effective.

CONCLUSION

In conclusion, integrating theoretical knowledge with practical project tasks is crucial when preparing future engineers for design and engineering activities based on a competency-based approach. The staged model of the PBL method unifies activities—such as problem identification, idea generation, 3D modeling, the preparation of drawings and specifications, and project defense—into a cohesive process. The comprehensive application of these methodological solutions facilitates an educational process aimed at developing the professional, technological, creative, and information-communication competencies of future engineers.

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