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THEORETICAL AND PEDAGOGICAL FOUNDATIONS FOR THE USE OF ARTIFICIAL INTELLIGENCE IN TEACHING CONSTRUCTION DRAWING IN HIGHER EDUCATION, AND REQUIREMENTS FOR DEFINING ITS CONTENT

Gulnoza Zokhidjon qizi Khusnidinova
Independent Researcher, Qori Niyoziy Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIAME), Tashkent, Uzbekistan

Abstract This article investigates the theoretical and pedagogical foundations for applying artificial intelligence (AI) technologies in teaching Construction Drawing in higher education, together with the broader problem of establishing a scientifically grounded pedagogical framework for this process. Drawing on the scholarship of both domestic and international researchers, the study analyzes the discipline's role within higher engineering education and its contribution to developing students' graphic literacy, spatial reasoning, and professional competencies. On this basis, the author formulates and substantiates eight pedagogical requirements for structuring the use of AI in this domain: scientific validity and professional relevance, sequential and stage-based progression, development of critical thinking, didactic appropriateness, practical and project-based orientation, integrativeness, ethical and professional responsibility, and transparency of assessment criteria. The study further offers a theoretical analysis of the dual objective inherent in integrating AI tools into engineering education: preparing students to use modern digital tools effectively while ensuring the durable formation of the discipline's core knowledge and skills.

Keywords: artificial intelligence; construction drawing; higher education; graphic literacy; spatial reasoning; pedagogical requirements; professional competence; educational content; digital technologies; critical thinking; BIM technologies.

1. Introduction The accelerating integration of digital technologies and artificial intelligence into education is transforming the learning process at every level. This shift is particularly consequential in engineering and technical fields—including architecture and construction—where the effective use of modern technology in teaching graphic disciplines has become an increasingly urgent concern.

Construction Drawing occupies a fundamental position in the training of architecture and construction specialists. The discipline cultivates spatial imagination, graphic literacy, technical and constructive reasoning, competence in working with regulatory-technical documentation, and design skills. In practice, however, many higher education institutions continue to rely predominantly on traditional, static teaching methods, which limits students' ability to fully grasp complex graphic concepts.

The urgency of this problem stems largely from the widening gap between rapid technological change in the construction industry and methodological stagnation in higher education. As the construction and design sector moves decisively toward comprehensive digital modeling—Building Information Modeling (BIM)—and intelligent design systems, conventional methods of developing future engineers' graphic literacy no longer yield the outcomes the

profession requires. Consequently, a clear methodological gap has opened between prevailing pedagogical practice and industry expectations.

The recent advancement of artificial intelligence technologies offers new possibilities for narrowing this gap. Rather than functioning as a purely technical instrument, AI can serve as a didactic transformer of education, enabling: dynamic visualization of complex graphic and spatial models through neural networks; automated, real-time detection and analysis of students' graphic errors; the design of individualized (adaptive) learning trajectories that account for each student's pace of mastery, ability, and characteristic error patterns; and the creation of interactive learning environments through generative AI and 3D modeling tools.

At the same time, incorporating AI tools into the content of Construction Drawing instruction without a systematic pedagogical framework risks undermining the discipline's core didactic aim—the formation of independent graphic thinking. The didactic potential of this integration, its effects on the learning process, and its methodological implications remain insufficiently researched, underscoring the need for dedicated scholarly inquiry. The purpose of the present study is therefore twofold: first, to clarify the theoretical and pedagogical foundations for using artificial intelligence in teaching Construction Drawing; and second, to develop scientifically grounded pedagogical requirements for defining the content of this use.

2. Literature Review The theoretical foundations of construction drawing and engineering graphics have been examined extensively in the scholarly literature. R.H. Khorunov identifies graphic training as a principal factor in the development of students' spatial thinking, arguing that drawing instruction enables students to understand the geometric structure of objects, represent them in multiple projections, and form spatial imagination [7].

Yu. Qirg'izboyev demonstrates that applying modern pedagogical technologies to drawing instruction improves educational effectiveness, and highlights the importance of designing systems of graphic assignments that integrate theoretical knowledge with practice [8].

Sh. Murodov's research addresses the broader improvement of drawing-instruction methodology, particularly the development of students' graphic competencies in higher education, and underscores the need for a systematic instructional approach [9].

N.A. Muslimov advances a competency-based approach to teaching technical disciplines, positioning graphic literacy as an integral component of the modern engineering specialist's professional profile [10]. Among international scholars, V.A. Gerver and A.D. Botvinnikov have contributed substantially to this field. Gerver treats graphic training as foundational to engineering education and provides a theoretical account of how drawing instruction shapes technical reasoning, while Botvinnikov emphasizes the centrality of constructive thinking in engineering-graphics education [11, 12]. N.N. Anisimov and I.A. Roytman analyze the didactic system underlying the drawing course and argue for its recognition as a fundamental discipline within higher education [13].

The application of digital tools in engineering education has likewise received considerable attention. Much of this literature addresses the didactic potential of integrating CAD/BIM technologies into graphic disciplines; however, the pedagogical organization of AI's generative and automated functions specifically within Construction Drawing remains underdeveloped. Existing

studies largely describe technological capabilities without offering a coherent set of pedagogical criteria to govern their inclusion in educational content—a gap that establishes the scientific novelty and rationale for the present study.

3. Results and Discussion

3.1. The Place of Construction Drawing in Higher Education Construction Drawing instruction in higher education is designed to equip students with both the theoretical and practical grounding required for developing construction projects. Through this discipline, students acquire the ability to read and analyze diverse types of drawings and to produce graphic documentation independently. Within the contemporary educational paradigm, cultivating students' independent reasoning, problem-solving capacity, and innovative thinking is central to teaching technical disciplines, and Construction Drawing plays a decisive role in developing precisely these competencies.

Synthesizing the perspectives reviewed above, the role of Construction Drawing within higher education can be summarized across five dimensions: developing students' spatial reasoning; forming graphic literacy; advancing engineering and technical thinking; preparing students for design practice; and building professional competence.

3.2. The Didactic Potential of Artificial Intelligence Digital technologies and computer graphics are now firmly embedded in construction practice. Contemporary design workflows rely on software such as AutoCAD, Revit, and BIM platforms to produce construction drawings and digital project documentation. AI-based systems further extend this capability, enabling the rapid generation of complex graphic models, automated analysis of drawings, and the development of alternative design solutions.

Traditional instructional methods deliver content at a uniform pace and depth to all students, which inevitably falls short of meeting individual learning needs. Artificial intelligence, by contrast, can analyze each student's specific weaknesses and generate targeted supplementary assignments addressing those areas, while relieving instructors of routine, repetitive technical checking. This capability, in turn, contributes to a more transparent and objective system of monitoring and assessment.

3.3. Pedagogical Requirements for Defining the Content of AI Use Integrating artificial intelligence tools into the content of Construction Drawing requires addressing a two-dimensional task: preparing students to use modern digital tools effectively, while ensuring the durable formation of the discipline's fundamental knowledge and skills. Based on the study's findings, the following eight pedagogical requirements were developed and substantiated for defining this content:

1. Scientific validity and professional relevance. Every AI-based tool or method incorporated into the curriculum must conform to current regulatory documents in the construction and architecture field (building codes, state standards, and unified design-documentation standards) and must be directly relevant to future engineering practice.

2. Sequential and stage-based progression. Content should be structured in stages aligned with students' level of graphic literacy: foundational drawing skills are consolidated first, after

which AI functions are introduced progressively. This sequencing prevents premature dependence on the tool.

3. Development of critical thinking. Content should be designed so that students are able to independently verify, evaluate, and, where necessary, correct any drawing or solution generated by artificial intelligence.

4. Didactic appropriateness and accessibility. The functional scope of AI tools must be selected in accordance with students' developmental characteristics, prior preparation, and cognitive capacity.

5. Practical and project-based orientation. Content should extend beyond theoretical instruction to be consolidated through concrete, project-based design assignments.

6. Integrativeness. Content related to artificial intelligence should be developed in close coordination with related disciplines, including engineering graphics, building structures, and information technology.

7. Ethical and professional responsibility. The curriculum must explicitly cultivate students' understanding of the professional and ethical boundaries governing the use of artificial intelligence.

8. Transparency of assessment criteria. Content should be structured so that work completed independently by the student can be clearly distinguished from work completed with AI assistance, and assessed accordingly.

To clarify the interrelationship among these requirements and their functional role within the educational process, they are systematized in Table 1.

Table 1. Functional orientation of the pedagogical requirements

No.	Requirement	Primary Function
1	Scientific validity and professional relevance	Aligns content with regulatory standards and professional practice
2	Sequential, stage-based progression	Introduces AI functions in line with students' preparedness
3	Development of critical thinking	Builds the capacity to independently evaluate AI-generated solutions
4	Didactic appropriateness and accessibility	Matches tool capabilities to students' cognitive level
5	Practical, project-based orientation	Reinforces theory through applied design tasks
6	Integrativeness	Ensures coherence across related disciplines

No.	Requirement	Primary Function
7	Ethical and professional responsibility	Establishes the professional and ethical limits of use
8	Transparency of assessment criteria	Distinguishes and evaluates independent versus AI-assisted work

The analysis indicates that the eight requirements form two functional groups. The first group (Requirements 1, 4, and 6) establishes the scientific-didactic foundation of the content, while the second group (Requirements 2, 3, 5, 7, and 8) defines the mechanism for its practical implementation. The interaction between these two groups enables the concurrent development of students' technical skills alongside their professional responsibility and independent critical judgment.

4. Conclusion The findings of this study demonstrate that clarifying the theoretical and pedagogical foundations for using artificial intelligence in teaching Construction Drawing, and defining the content of this use on a scientifically grounded basis, constitute an important methodological task for contemporary engineering education. The discipline should be regarded not only as a source of theoretical knowledge but also as a principal instrument of students' professional formation; the study confirms the corresponding need to integrate AI tools into its content in a systematic and pedagogically grounded manner.

The literature review shows that, while the theoretical and methodological foundations of construction drawing and engineering graphics have been extensively studied by domestic and international scholars, a coherent set of requirements governing the pedagogically sound use of artificial intelligence within this specific discipline had not previously been developed as an independent object of research. The present study addresses this methodological gap, linking theoretical analysis with practical necessity.

The study analyzed the theoretical foundations of integrating artificial intelligence tools into the educational process and developed and substantiated eight pedagogical requirements for shaping the content of their use in Construction Drawing. These requirements are closely interconnected and together constitute the methodological basis for the systematic integration of AI tools into instruction. Specifically, the requirements of scientific validity and professional relevance, didactic appropriateness, and integrativeness establish the content's scientific-theoretical foundation, while sequential progression, development of critical thinking, practical and project-based orientation, ethical and professional responsibility, and transparency of assessment criteria define the concrete mechanism for translating this content into practice. This two-tier structure—theoretical and practical—supports the coordinated development of students' technical competence together with their professional responsibility and capacity for independent critical thinking.

The analysis further indicates that the pedagogically grounded use of artificial intelligence can enhance students' graphic literacy, expand spatial imagination, support the visualization of complex drawings, enable rapid detection of graphic errors, and facilitate individualized learning trajectories. In addition, this approach relieves instructors of repetitive technical verification, allowing greater focus on creative and individualized engagement with students—an important

contributor to overall educational quality. At the same time, the requirements framework developed here helps prevent adverse outcomes that may arise from uncontrolled or unsystematic AI use, including tool dependency, diminished independent graphic reasoning, and threats to academic integrity.

The practical significance of these findings lies in their applicability to improving working curricula, instructional-methodological complexes, and assessment criteria for Construction Drawing and related engineering-graphic disciplines in higher education. Specifically, the requirements can inform the design of AI-integrated assignment banks, the development of methodological guidance for instructors, and the creation of assessment rubrics that distinguish between and evaluate independent and AI-assisted student work.

The scientific novelty of this study lies in its integration of the theoretical-pedagogical foundations of AI use in Construction Drawing and the requirements for shaping its content into a coherent framework, together with a substantiation of its didactic significance. These findings provide a foundation for further research, including experimental pilot testing of the proposed requirements framework, evaluation of its impact on educational quality through quantitative and qualitative indicators, and investigation of its applicability to related engineering-graphic disciplines such as engineering graphics and the fundamentals of technical drawing. This constitutes a priority direction for subsequent stages of the author's dissertation research—namely, the empirical validation of the theoretical-methodological framework developed here and the experimental demonstration of its effectiveness.

References

1. Decree of the President of the Republic of Uzbekistan No. PF-60, "On Approval of the 'Digital Uzbekistan – 2030' Strategy." Tashkent, 2020.
2. Avdeev, F.S. Methodology of Teaching Engineering Graphics Using Information Technologies. Moscow: Vysshaya Shkola, 2019. 184 p.
3. Tojiboyev, K.S. Methodology of Using Modern Information Technologies in Teaching Engineering Graphics. Tashkent: Fan va Texnologiya, 2021. 156 p.
4. Russell, S., Norvig, P. Artificial Intelligence: A Modern Approach, 4th ed. Pearson, 2021. 1136 p.
5. Eastman, C., Teicholz, P., Sacks, R., Liston, K. BIM Handbook: A Guide to Building Information Modeling, 3rd ed. Wiley, 2018. 688 p.
6. Yusupova, M.A. Forming Digital Competencies in Teaching Graphic Disciplines in Higher Education Institutions. Abstract of Candidate of Pedagogical Sciences dissertation. Tashkent.
7. Khorunov, R.H. The Role of Graphic Training in Developing Students' Spatial Thinking. Problems of Higher Education, Tashkent, 2020, No. 3, pp. 45–52.
8. Qirg'izboyev, Yu. Applying Modern Pedagogical Technologies in Teaching Drawing. Education and Development, Tashkent, 2021, No. 2, pp. 33–40.

9. Murodov, Sh. Improving the Methodology of Teaching Drawing in Higher Education. Tashkent: Fan, 2019. 180 p.

10. Muslimov, N.A. A Competency-Based Approach to Teaching Technical Disciplines. Pedagogical Education, Tashkent, 2022, No. 1, pp. 12–18.

11. Gerver, V.A. Graphic Training as the Foundation of Engineering Education. Moscow: Vysshaya Shkola, 2018. 210 p.

12. Botvinnikov, A.D. The Development of Constructive Thinking in the Engineering Graphics Course. Pedagogy of Higher School, Moscow, 2017, No. 4, pp. 67–74.

13. Anisimov, N.N., Roytman, I.A. The Didactic System of the Drawing Course in Higher Education. Moscow: Prosveshchenie.