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MECHANISMS FOR IMPROVING THE METHODOLOGY OF TEACHING STUDENTS TO USE ARTIFICIAL INTELLIGENCE IN CONSTRUCTION DRAWING CLASSES

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Abstract. This article provides a pedagogical and methodological analysis of ways to improve the methodology for teaching students to use artificial intelligence (AI) technologies in construction drawing and engineering graphics education. It proposes a four-component pedagogical mechanism—goal-oriented, content-related, procedural, and outcome-diagnostic—for systematically integrating traditional drafting education (freehand sketching, descriptive geometry, and ESKD/SHNK standards) with modern digital technologies (CAD/BIM, generative AI, computer vision, and parametric prompting). The article examines a step-by-step method for automatically converting 2D drawings into 3D models using Image-to-BIM technology, as well as a mechanism for automatically analysing and correcting drawing errors with AI. It also presents a standards-based prompt-engineering structure (GOST/ESKD/SPDS, SHNK) and a sample practical assignment. The findings indicate that AI technologies should be used as tools for enhancing students' creative and analytical potential, rather than replacing the fundamental knowledge base of engineering graphics.
Keywords: construction drawing, engineering graphics, artificial intelligence, BIM, Image-to-BIM, parametric prompting, generative design, pedagogical mechanism, computer vision, ESKD/SPDS, SHNK.

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Abstract. The article examines the improvement of the methodology for teaching students to use artificial intelligence (AI) technologies in construction drawing and engineering graphics courses. A four-component pedagogical mechanism (goal-oriented, content-related, procedural, and outcome-diagnostic) is proposed for integrating traditional drafting (manual sketching, descriptive geometry, and ESKD/SPDS and SHNK standards) with digital technologies (CAD/BIM, generative AI, computer vision, and parametric prompting). A step-by-step methodology for automatically converting 2D drawings into 3D/BIM models (Image-to-BIM), as well as a mechanism for AI-based automatic analysis and correction of drawing errors, is considered.
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INTRODUCTION

Improving the methodology for teaching students to use artificial intelligence (AI) in construction drawing classes is one of the most pressing areas in contemporary pedagogy and digital engineering education. Architecture and construction are rapidly adopting technologies such as parametric design, BIM (Building Information Modeling), and generative design. Consequently, continuing to teach drafting solely through traditional methods may reduce graduates' competitiveness in the labour market.

The relevance of this problem is determined by several factors. First, productivity and speed can be increased: tools such as Midjourney, Stable Diffusion, Autodesk FormIt/Revit AI plugins, and Spacemaker can generate several conceptual drawing options, 3D visualisations, and model structures within seconds. Second, AI technologies can automatically analyse technical errors in drawings and check their compliance with construction regulations (SHNK/GOST) and safety requirements. Third, the international labour market increasingly requires engineers who can work not only with CAD/BIM software but also with AI generators integrated into these systems.

At the same time, AI cannot replace the fundamentals of drafting and engineering in the classroom; it serves only as a tool for enhancing students' creative and technical potential. Focusing the teaching methodology on this principle enables higher education institutions to prepare modern, competitive specialists. The aim of this article is to develop a pedagogical and methodological mechanism that systematically combines traditional and digital-intelligent approaches in construction drawing education and to substantiate its practical model.

STATE OF RESEARCH ON THE PROBLEM

In traditional engineering graphics education, students' acquisition of graphical information has largely relied on spatial visualisation and repeated drafting exercises. Although local and international researchers have separately studied the integration of BIM technologies into engineering education, the foundations of generative design, and the use of computer vision to automatically analyse engineering drawings, most of this work has focused on technological aspects rather than bringing them together into a coherent didactic and methodological system. In particular, the pedagogically grounded, step-by-step integration of traditional drafting skills (freehand sketching and descriptive geometry) with AI tools has not been sufficiently examined as a distinct research subject. This gap defines the scientific novelty of the present study.

RESEARCH METHODOLOGY

The study used methods of pedagogical system design, the competency-based approach, content analysis, and practical modelling. The theoretical foundation of the pedagogical-methodological mechanism was the theory of the holistic pedagogical process, including its goal-oriented, content-related, procedural, and outcome-diagnostic components. The practical section was substantiated by modelling the use of AI tools through a representative construction drawing assignment: the floor plan and section of a two-storey residential building.

ANALYSIS AND RESULTS

Structure of the pedagogical and methodological mechanism

A pedagogical mechanism is an integrated, sequential system of methods, forms, tools, and stages of activity that guides the teaching and learning process towards a planned outcome. It acts as the driving force that translates educational content into practice and consists of four main components:

1. 1. Goal-oriented component — defines state educational standards, curricula, and lesson objectives. Objectives should be clear, measurable, and achievable.

2. 2. Content-related component — comprises the knowledge, skills, abilities, and competencies to be developed in students, as reflected in curricula, textbooks, and teaching materials.

3. 3. Procedural component — covers teaching methods and formats (lectures, practical classes, and seminars), educational technologies, and the dynamics of teacher–student collaboration.

4. 4. Outcome-diagnostic component — includes comparing achieved outcomes with objectives, assessment methods (tests, examinations, and projects), and methodological adjustments.

SYSTEMATIC INTEGRATION OF TRADITIONAL AND DIGITAL SKILLS

In construction drawing, integrating traditional education (manual drafting, fundamental geometry, and ESKD/SHNK standards) with digital technologies (CAD/BIM) is a key stage in engineering education. Relying exclusively on traditional drafting can disconnect students from the modern labour market, while abandoning the traditional foundations and moving directly to CAD systems can lead to design without understanding—that is, without grasping the underlying engineering logic.

Therefore, skills should be integrated progressively throughout the learning process. Freehand sketching develops spatial and shape perception and establishes the basis for 3D thinking. Practising standards manually teaches line types, scale, dimensioning, and SHNK requirements. A conceptual hand-drawn sketch is then converted into a 2D CAD drawing (AutoCAD/Kompas-3D) and subsequently into a 3D BIM model (Revit). Viewing the resulting BIM models using AR/VR tools helps students understand software as a tool, while independently comprehending the structural and physical logic of the design.

AI AS A DIDACTIC TOOL: PRINCIPLES

The introduction of AI technologies into engineering graphics education is an objective didactic necessity that can raise educational effectiveness to a new level. However, AI does not replace fundamental descriptive geometry, the logic of standards, or sketching skills. The key principles for using AI in education are presented in Table 1.

Table 1

Key principles for using AI in education

Principle	Description and practical application
Human-in-the-Loop	AI is an assistive tool, not a provider of ready-made solutions. The student and teacher retain final responsibility for assessing the technical correctness of the drawing and its compliance with standards.
Constructive and algorithmic thinking	Through parametric prompting, students learn not merely to draw an object, but to express its geometric relationships and parametric structure in algorithmic language.
Automated feedback (Instant Feedback)	Computer vision algorithms quickly identify sequencing errors in drawings (joins, sections, and line weights), reducing the teacher's monitoring workload.
Variation and idea generation	Generative AI can produce dozens of structural concepts for a single engineering assignment, from which the most suitable option can be selected.

Principle	Description and practical application
Standardisation and compliance (Accreditation and state educational standards)	All generative and parametric outputs must strictly comply with state educational standards and drafting rules.

PARAMETRIC PROMPTING AND AN EXAMPLE OF A PRACTICAL ASSIGNMENT

Parametric prompting is a method of conveying the geometric dimensions, proportions, and constraints of a drawing or object (for example, L = 120 mm, R = 15 mm, Symmetry = True) to an AI system as precise mathematical and algorithmic instructions. In construction drawing, it helps develop accuracy and an understanding of parametric modelling. In engineering drawing, such a prompt can follow this template: [Object type] + [Geometric dimensions] + [Projection/views] + [Constraints and relationships] + [Standard/drafting rule].

The following assignment illustrates this approach: draw the ground-floor plan and a vertical section of a two-storey residential building on an A3 sheet (420 × 297 mm) at a scale of 1:100. The assignment specifies the grid axes (longitudinal axes A, B, V; transverse axes 1, 2, 3), distances between axes (1–2 = 4500 mm; 2–3 = 3600 mm; A–B = 6000 mm; B–V = 4000 mm), wall thicknesses (external brick wall — 510 mm; internal load-bearing wall — 380 mm; partition wall — 120 mm), opening dimensions (window 1500 × 1500 mm; entrance door 1000 × 2100 mm; internal door 800 × 2100 mm), and elevation marks (±0.000; −0.900; +3.300; +7.500). This fully parameterised assignment enables students to obtain a 2D drawing from AI and then generate a 3D axonometric model, including a building section. This supports simultaneous analysis of structural elements and their relative proportions from both exterior and interior perspectives.

IMAGE-TO-BIM: A METHOD FOR CONVERTING 2D DRAWINGS INTO 3D MODELS

The automatic conversion of 2D drawings into 3D/BIM models is the process of transforming paper-based or raster drawings (JPG, PNG, PDF) into three-dimensional objects using computer vision, neural networks, and parametric algorithms. It consists of four technological stages:

1. Image processing and segmentation — remove noise and use deep-learning neural networks to classify walls, openings (windows/doors), text, and symbols (dimension lines, grid axes, and elevation marks).

2. Vectorisation and axis-line detection — convert raster pixels into geometric vectors using Hough Transform and contour detection, and identify the centre lines of walls.

3. Semantic and topological graph construction — identify relationships between walls and openings (intersections and positions), calculate room outlines and areas, and create a room-schedule graph.

4. BIM parameterisation and 3D modelling — transfer geometric and topological data to Revit/ArchiCAD/IFC formats, assign height and material parameters to wall vectors, and automatically place parametric 3D families for doors and windows.

The pedagogical effectiveness of this methodology is evident in three areas: time savings (70–80% of the process of rebuilding a 3D model from a 2D drawing can be automated), rapid feedback and diagnostics (students receive immediate reports on geometric errors in their drawings), and the

development of spatial thinking (the relationship between a 2D plan/section and a 3D volume is made clear).

STANDARDS-BASED PROMPT ENGINEERING AND AUTOMATED ERROR ANALYSIS

Integrating prompt engineering with GOST (ESKD/SPDS) and SHNK (urban planning norms and rules) helps ensure the technical and regulatory accuracy of AI-generated outputs. A standards-based prompt is not merely a textual description; it is an algorithmic engineering task (DZT) consisting of five mandatory blocks: object type and purpose; precise geometric parameters; required projections and views; structural constraints and relationships; and the applicable standard or drafting rule.

The mechanism for automatically analysing and correcting errors in students' drawings is based on integrating computer vision with geometric/vector-analysis algorithms and provides real-time feedback. The didactic effectiveness of this mechanism can be seen at three levels:

For students — immediate online feedback; explanations of the regulatory basis for each error (the relevant ESKD/SPDS provision); development of self-monitoring and reflection skills; and reduced subjectivity in assessment.

For teachers — a 70–80% reduction in time spent on routine checking; identification of individual student difficulties and implementation of differentiated instruction; and access to statistics on the most common errors across a group.

For educational institutions — development of a digital didactic ecosystem integrated with an LMS/Moodle, improved indicators of learning quality, and greater transparency in accreditation and monitoring.

A STEP-BY-STEP ALGORITHM FOR IMPLEMENTING THE METHODOLOGY

Based on the analysis, a three-stage algorithm is recommended for introducing the AI-based methodology into the learning process:

1. Preparatory stage — develop basic graphic literacy and introduce students to AI tools (Midjourney, DALL-E, AutoCAD AI add-ins, and Stable Diffusion ControlNet).

2. Practical project stage — create façade and floor-plan drawings using parametric prompts and develop constructive and algorithmic thinking.

3. Analysis and monitoring stage — identify and correct engineering and visual errors in drawings using AI-based checks (automated clash detection).

CONCLUSION

The analysis indicates that introducing AI into engineering and construction drawing education is not simply a matter of equipping education with technical tools; it represents a fundamental transformation of the pedagogical paradigm.

The proposed four-component pedagogical mechanism (goal-oriented, content-related, procedural, and outcome-diagnostic) is expected to produce the following outcomes:

Methodological renewal — students progress from mechanically reproducing ready-made graphical images to becoming design engineers who can critically analyse AI-generated outputs against SHNK and ESKD/SPDS standards and express solutions algorithmically.

Integrated skills — theoretical drafting knowledge (projections, sections, and sectional views) is combined with the ability to formulate effective prompts for neural networks, allowing traditional graphic literacy and generative thinking to develop in parallel.

Quality and safety assurance — the human factor (student/teacher) remains central to the learning process. AI serves as a tool for rapid generation and automation, while the student remains the principal decision-maker responsible for regulatory and technical compliance.

Thus, the proposed mechanism helps align the training of construction drawing specialists with the requirements of the digital economy and the modern construction industry.

Future research should empirically test this mechanism through pedagogical experiments in different higher education institutions and quantitatively evaluate its effect on students' learning outcomes.

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