Research on Blended Teaching Reform of Engineering Drawing Course Empowered by AI Application on the BOPPPS Model

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Abstract. With the rapid development of generative artificial intelligence technology, higher education is undergoing a profound transformation from the traditional "teacher-student" dual structure to a "teacher-AI-student" triadic structure. As a core course for logistics major, Engineering Drawing faces practical challenges such as insufficient student engagement due to the widespread use of AI tools. Based on the BOPPPS teaching model, this study takes the "Logistics Engineering CAD" course of the Logistics Management major at Shenzhen Technology University as an example, and constructs a blended teaching model with triadic collaboration among teachers, AI, and students. This paper elaborates on the role positioning and collaborative mechanisms of teachers, AI, and students in three stages—pre-class, in-class, and post-class—and demonstrates the implementation pathway of AI-empowered teaching through specific course chapters, providing a referable practical framework for the intelligent teaching reform of engineering practice-oriented courses.

Keywords: Artificial Intelligence, BOPPPS Teaching Model, Logistics Engineering CAD, Blended Teaching, Triadic Collaboration.

1 Introduction

Currently, artificial intelligence is reshaping educational paradigms and talent cultivation models at an unprecedented pace [1]. The report of the 20th National Congress of the Communist Party of China explicitly called for "advancing educational digitalization," and the Outline of the Plan for Building a Strong Education Nation (2024–2035) emphasizes "promoting artificial intelligence to empower educational transformation." In this context, how to transform AI technology from students' "homework assistant" into "learning partner," and how to prevent AI tools from eroding students' capacity for deep thinking, have become urgent questions that higher education must address.

Originating from the Instructional Skills Workshop (ISW) in Canada in the 1970s, the BOPPPS teaching model is learner-centered and comprises six phases: Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, and Summary. It emphasizes students' active engagement and real-time feedback on teaching effectiveness, and has been widely adopted by higher education institutions in 33 countries [2].

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In recent years, scholars have begun exploring pathways for integrating the BOPPPS model with AI technology, with applications reported in courses such as Statistics [3], Pathophysiology [4], and others. Relevant studies indicate that AI can effectively empower all phases of BOPPPS [5] through intelligent diagnostic assessment of learning status [6], personalized resource recommendation [7], and real-time interactive feedback [8], thereby enhancing teaching efficiency and learning outcomes. However, research on AI-empowered BOPPPS-based teaching practices specifically tailored to engineering practice-oriented courses—and particularly to Logistics Engineering CAD—remains scarce.

Logistics Engineering CAD is a specialized course offered by our university for Logistics Management majors, designed to cultivate students' engineering practice competencies in employing CAD software for logistics system planning, warehouse layout design, and facility and equipment selection. As a practice-oriented course, it encompasses modules such as fundamental drafting knowledge, orthographic projection principles, AutoCAD operations, logistics equipment drawing, and transfer terminal planning and design. However, against the backdrop of the rapid proliferation of AI technologies, the course confronts three major challenges. First, students commonly resort to various AI tools to complete assignments, bypassing deep engagement with foundational knowledge such as projection principles and dimensioning standards—the "one-click generation" phenomenon leads to diminished metacognitive engagement. Second, the traditional "lecture-plus-computer-lab" teaching model struggles to align with the changing cognitive patterns of contemporary students, who prefer visual and fragmented learning approaches. Third, the industry-education integration resources collaboratively developed with enterprises such as SF Express have not yet been systematically incorporated into the course content, and a mechanism for introducing authentic enterprise projects into the classroom urgently needs to be established. In response to these challenges, this study embeds AI-assisted tools throughout the entire teaching process of the Logistics Engineering CAD course, constructs a "teacher–AI–student" triadic collaborative blended teaching model based on the BOPPPS framework, and explores effective pathways for AI-empowered teaching reform in engineering practice-oriented courses.

2 Instructional Design Framework of AI-Empowered BOPPPS Model

2.1 Adaptability Analysis of the BOPPPS Model to the Logistics Engineering CAD Course

The Logistics Engineering CAD course features a distinctive "learning by doing" character. The in-class practice includes experimental projects covering hand-drawn basic graphics, CAD command operations, logistics equipment drawing, dynamic block creation, and integrated transfer terminal design, with difficulty progressing incrementally from "verificative" to "exploratory" levels. This practice-oriented structure with clear

skill progression aligns closely with the BOPPPS model's emphasis on "participatory learning" and "real-time feedback."

The six phases of the BOPPPS model provide a clear structural framework for course instruction: the Bridge-in phase can leverage AI to create authentic engineering scenarios; the Objective phase can utilize AI assistance to develop tiered learning objectives; the Pre-assessment phase can employ AI to generate diagnostic tests and analyze student learning profiles; the Participatory Learning phase can introduce AI as a "design assistant" or "compliance reviewer"; the Post-assessment phase can harness AI for immediate evaluation and feedback; and the Summary phase can rely on AI to generate personalized review resources and learning analytics reports. This framework effectively addresses the pain points of traditional CAD courses, such as low student participation and untimely feedback.

2.2 Reconstruction of Teaching Subjects through "Teacher–AI–Student" Triadic Collaboration

Under the traditional "teacher–student" dual teaching model, the teacher serves as the sole transmitter of knowledge while students remain passive recipients. With the rise of generative artificial intelligence, education is transitioning from the dual model to a "teacher–AI–student" triadic model. This study positions AI-assisted tools in the dual role of "intelligent teaching assistant" and "intelligent learning companion," with specific role divisions as follows:

The teacher's role: Responsible for instructional design, classroom organization, explanation of key and difficult points, project review, and value guidance—transitioning from "knowledge transmitter" to "learning designer" and "project mentor." In the Fundamentals section, the teacher focuses on systematic explanation of drafting standards and operational demonstrations; in the Professional Practice section, the teacher emphasizes design task assignment, team collaboration organization, and design solution evaluation.

The AI's role: Performs three functions. First, as an "intelligent teaching assistant," it supports the teacher in completing routine tasks such as learning analytics, resource generation, and assignment compliance checking. Second, as an "intelligent learning companion," it provides students with personalized learning recommendations, real-time Q&A, and design suggestions. Third, as an "intelligent examiner," it automatically generates test questions and assesses learning outcomes during the Pre-assessment and Post-assessment phases.

The student's role: Upgraded from passive recipient to active inquirer. In the Fundamentals section, students construct knowledge of drafting standards through interaction with AI; in the Professional Practice section, students complete authentic enterprise project designs in teams, and through iterative interactions with both the teacher and AI, achieve the capability progression from "imitative operation" to "independent design."

3 Three-Phase Collaborative Teaching Practice Based on the BOPPPS Model

The following section uses the teaching unit "General Layout of Logistics Transfer Terminals" (corresponding to Chapter 14 of the textbook [9]) in the Logistics Engineering CAD course as an example to demonstrate the specific implementation pathway of the AI-empowered BOPPPS model.

3.1 Pre-class Stage: Context Creation and Learning Diagnosis

The pre-class stage corresponds to the Bridge-in, Objective, and Pre-assessment phases of the BOPPPS model, and is primarily accomplished through online learning and interaction.

Bridge-in.

Teacher's role: Instructional designer. Based on the teaching objectives of each unit, the teacher determines the theme and format of the contextual introduction and designs guiding questions. In this unit, the teacher establishes "planning of a logistics transfer terminal within the SF Express network structure" as the case background and devises engaging introductory questions.

AI's role: Content generator and context creator. The teacher imports course lecture notes and desensitized cases into the AI knowledge base, and designs prompts to guide the AI in generating case background documents and guiding questions. For example, the teacher inputs the prompt: "Please, acting as a logistics planner, introduce the basic functional requirements, area constraints, and operational process requirements of a medium-sized logistics transfer terminal, and design three guiding questions." Based on this, the AI generates case materials including key information such as daily processing capacity, functional area requirements, site constraints, and corresponding questions.

Student's role: Context perceiver and interest activator. Students read the AI-generated case materials through the online platform, contemplate the guiding questions, gain an initial understanding of the real engineering scenarios of transfer terminal planning, and establish learning expectations.

Objective.

Teacher's role: Objective setter. Based on the course syllabus requirement to "master the analytical key points and drawing procedures of three typical schemes in the relationship between logistics transfer terminals and road layout," the teacher determines the core learning objectives for this unit.

AI's role: Objective optimizer and tiered recommendation provider. The teacher inputs the curriculum standards and draft learning objectives into the AI, which assists in

generating qualitative objectives, knowledge objectives, and skill objectives, and provides recommendations for differentiated objectives tailored to students at different levels.

Student's role: Objective comprehender. Students clarify the learning objectives and assessment criteria for this unit through the online platform, establish a "roadmap" for learning, and ensure they understand the key points of the class beforehand.

Pre-assessment.

Teacher's role: Test designer and strategy adjuster. The teacher determines the content scope and question-type structure of the pre-assessment, and adjusts the focus and pace of classroom instruction based on the AI-generated learning analytics report.

AI's role: Test generator and learning analyst. The AI automatically generates pre-assessment questions based on the knowledge base content and pushes them to students through the online platform. After students complete their responses, the AI automatically grades objective questions and generates a learning analytics report.

Student's role: Self-diagnostician. By completing the pre-assessment, students understand their mastery of prerequisite knowledge, identify their weak areas, and make targeted preparations for classroom learning.

3.2 In-class Stage: Human-AI Collaboration and Deep Engagement

The in-class stage corresponds to the Participatory Learning and Post-assessment phases of the BOPPPS model, and serves as the most concentrated embodiment of triadic collaboration.

Participatory Learning.

As the core phase of the BOPPPS model, it is designed as a three-stage progressive structure of "teacher-led instruction – AI-assisted demonstration – group-based practice," in which teachers, AI, and students each fulfill their respective roles and interact collaboratively.

(1) Stage One: Teacher-led Instruction on Drafting Standards and Design Principles.

Teacher's role: Knowledge lecturer and standards interpretation expert. The teacher systematically explains the site selection principles, overall planning elements, general layout methods, and fire compartment requirements for logistics transfer terminals using PowerPoint presentations.

AI's role: Real-time Q&A assistant. During the teacher's instruction, the AI serves as a "real-time knowledge base" to address students' immediate questions. It retrieves relevant standards and content from the knowledge base and responds promptly, resolving students' queries as they arise.

Student's role: Knowledge recipient and real-time questioner. Students listen to the teacher's systematic presentation while simultaneously posing immediate questions to the AI through the online platform, achieving "real-time clarification during instruction."

(2) Stage Two: AI-Assisted Design Demonstration.

Teacher's role: Task issuer and thinking guide. The teacher releases the design task—"Please complete a general layout design proposal for a third-party logistics transfer terminal, including unloading area, storage area, sorting area, shipping area, and AGV route planning"—and demonstrates how to conceptualize the solution with the assistance of AI.

AI's role: Solution generator and thinking scaffold provider. The teacher inputs design constraints into the AI, which generates preliminary design descriptions and schematic sketches including recommendations for functional zone division, aisle widths, and vehicle circulation. The teacher then guides students to analyze the rationality of the AI-generated solutions, points out potential shortcomings, and cultivates students' critical thinking.

Student's role: Analyst and critic. Students observe the process of AI solution generation, analyze the strengths and limitations of the AI's recommendations, and begin to formulate their own design ideas.

(3) Stage Three: Group-Based Practice and Real-Time AI Assistance.

Teacher's role: Project mentor and roving instructor. The teacher issues detailed design briefs and organizes students into groups of 4-5 to complete the transfer terminal general layout drawing in AutoCAD. The teacher roves around the classroom providing guidance, focusing on students' design thinking and team collaboration, and offers centralized explanations for common issues.

AI's role: Design consultant and compliance reviewer. When students encounter questions regarding design standards, parameter selection, or CAD operations during the drawing process, they may consult the AI at any time. The AI provides three types of real-time assistance: offering parameter recommendations based on standards, automatically reviewing layout compliance, and guiding CAD operations.

Student's role: Active designer and team collaborator. Students independently develop design solutions with AI assistance, deepening their understanding of design standards and cultivating their ability to solve complex engineering problems through an iterative cycle of "questioning–feedback–revision."

Post-assessment.

Teacher's role: Assessment standards setter and comprehensive reviewer. The teacher establishes the evaluation criteria for the post-assessment (including layer specification, dimensioning completeness, design solution rationality, and fire compartment compliance), and provides comprehensive feedback following peer evaluation.

AI's role: Preliminary assessment tool and data collector. After each group submits their DWG files, the AI automatically checks the drawings for compliance, generates a "Drawing Compliance Inspection Report," and provides data to support the teacher's evaluation.

Student's role: Peer evaluator and reflective practitioner. Groups score and comment on other groups' solutions through the online platform's rating function, focusing on the rationality and innovation of the design proposals. After receiving the AI-

generated inspection reports, students compare their own solutions against the standards, identify gaps, and engage in self-reflection.

3.3 Post-class Stage: Targeted Feedback and Continuous Improvement

The post-class stage corresponds to the Summary phase of the BOPPPS model, primarily consolidating learning outcomes and achieving continuous improvement through online learning and interaction.

Teacher's role: Reflective practitioner and driver of continuous improvement. The teacher collects AI-generated analytical reports and student feedback, evaluates the attainment of teaching objectives, identifies existing problems in instruction, and accumulates evidence for the next round of teaching optimization. Additionally, the teacher provides targeted tutoring to students experiencing learning difficulties.

AI's role: Knowledge integrator and personalized recommendation generator. The AI undertakes three specific tasks: knowledge summarization, personalized diagnosis, and teaching effectiveness analysis.

Student's role: Reflective summarizer and autonomous learner. Students consolidate knowledge through AI-generated review materials, understand their weaknesses through personalized diagnostic reports, and make targeted improvements. Students may also proactively request additional practice questions from the AI to achieve personalized extended learning.

4 Conclusion

This study deeply integrates AI-assisted tools with the BOPPPS teaching model to construct a "teacher–AI–student" triadic collaborative blended teaching model in the Logistics Engineering CAD course. The contributions are threefold. First, it clarifies the specific roles and collaborative mechanisms of teachers, AI, and students across the three stages of pre-class, in-class, and post-class, establishing a clear division of labor characterized by "teacher design and guidance – AI assistance and support – student active construction." Second, based on the distinct characteristics of the course's Fundamentals section and Professional Practice section, it devises differentiated AI intervention strategies, achieving a progressive capability development from "AI reading companion" to "AI design consultant." Third, it establishes a constraint mechanism to prevent AI from undermining deep learning, ensuring that AI consistently serves objective of "cultivating engineering thinking."

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