

Construction and Practical Exploration of an AIGC-Assisted Project-Based Teaching Model

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Abstract: Although traditional project-based learning (PBL) has proven effective in improving student engagement and practical ability in mechanical design related courses, it still suffers from weak alignment between course projects and real engineering practices, insufficient process evaluation, and limited personalized guidance. To address these issues, this study explores an AIGC-assisted PBL model. In the instructional design, AIGC is integrated throughout pre-class preparation, in-class teaching, after-class assignments, and group projects, supporting students in rapidly acquiring knowledge, generating design schemes, and conducting iterative optimization. Teaching practice shows that this model yields positive results in knowledge acquisition, ability development, and engineering literacy, effectively alleviating the pain points of traditional PBL. However, it is also observed that students' critical thinking and awareness of academic integrity still require further reinforcement. This AIGC-assisted PBL model provides a feasible pathway for the deep integration of "artificial intelligence + education" and offers valuable insights for curriculum reform under the background of emerging engineering education.

1. Introduction

Mechanical design related courses are among the core courses of mechanical engineering programs, featuring high comprehensiveness and strong practicality. Students are required not only to master fundamental theories and methods of mechanical structure design but also to apply such knowledge to solve real engineering problems. Project-Based Learning (PBL), with its emphasis on task-driven learning, teamwork, and authentic scenario simulation, is highly compatible with courses such as mechanical design related courses [1–3]. However, in traditional teaching practice, due to limited student knowledge reserves, time constraints, and project complexity, project studies often remain at a superficial level, making it difficult to achieve systematic optimization and in-depth refinement of design schemes.

In recent years, the rapid development of Artificial Intelligence Generated Content (AIGC) has brought new opportunities to higher education reform [4]. AIGC can not only generate preliminary schemes based on students' initial design ideas but also provide optimization suggestions from

multiple dimensions such as technical feasibility, economic rationality, and engineering implementability, thereby significantly enhancing the scientific rigor and completeness of design schemes. As a result, students are freed from repetitive labor and can devote more energy to problem abstraction, scheme selection, and comprehensive decision-making.

Nevertheless, the widespread application of AIGC has also raised new challenges [5]. Some students show excessive reliance on AI outputs and lack critical evaluation, which undermines their independent thinking and analytical ability while weakening their awareness of academic integrity. How to guide students to maximize AIGC's advantages while maintaining rationality, critical thinking, and reflection has become a key issue in teaching reform.

With the continuous advancement of emerging engineering education, course objectives are no longer limited to knowledge instruction but emphasize interdisciplinary integration and the cultivation of abilities to solve complex problems. Although AIGC has demonstrated potential in education, its application in highly practice-oriented courses such as Mechanical Design still lacks systematic exploration and empirical research. How to effectively implement "AI + education" in practice remains an urgent research topic.

Therefore, this study takes Mechanical Design as the research object to explore an AIGC-assisted PBL model. It focuses on analyzing the model's performance in course objective attainment, teaching process design, and practical outcomes, and further summarizes improvement pathways.

2. Overview and Analysis of Mechanical Design Courses

2.1. Course Characteristics

Mechanical design courses are core compulsory courses in mechanical engineering curricula, emphasizing the integration of theory and practice. Students are required not only to master the principles and calculation methods of component design but also to integrate knowledge from prerequisite courses such as mechanics, materials science, mechanical principles, and manufacturing processes into specific engineering tasks. Learning outcomes are typically assessed through practical products such as drawing design, 3D modeling, design reports, and project documentation. Consequently, the course highlights problem-solving and systems thinking as core educational goals, naturally aligning with the PBL approach.

2.2. Analysis of Teaching Pain Points

Despite its clear positioning, the course still faces several challenges in practice:

(1) Disconnection between theory and practice: Classroom teaching remains dominated by theoretical instruction. Students can complete written assignments but often lack the ability to apply knowledge to solve complex engineering problems, resulting in insufficient innovation and poor alignment with engineering requirements.

(2) Overly simplistic evaluation system: Current assessments focus heavily on final exams, with limited process evaluation and insufficient weight given to teamwork, leading to low motivation and sustained engagement.

(3) Outdated content and mismatch with industry needs: Course content often diverges from current industrial practices, limiting the cultivation of students' engineering application awareness.

(4) Resource constraints: PBL requires significant classroom and extracurricular time. Without sufficient teaching hours and online resources, theoretical teaching time is compressed, and both teachers and students face increased workload. Moreover, teachers' project management and formative evaluation skills are challenged.

(5) Uneven student capability structures: While some students possess solid theoretical foundations, many show weaknesses in hands-on skills, teamwork, documentation, and interdisciplinary collaboration, limiting project quality and outcomes.

2.3. Achievements and Problems of PBL

The introduction of PBL into Mechanical Design courses has yielded positive outcomes. The project-driven and group-based collaboration significantly enhance student engagement, hands-on ability, and higher-order thinking (e.g., critical and creative thinking), while boosting participation and achievement in academic competitions and research [6]. Teaching practice further shows that after implementing "project-driven + group collaboration," students' overall final scores improved, participation in competitions increased, and their engineering practice capabilities were significantly enhanced.

However, several issues remain. First, implementation and evaluation often overemphasize final project outputs while neglecting cognitive deepening in problem abstraction, scheme reasoning, and parameter optimization, limiting students' critical thinking and systemic analysis skills, with little attention to dynamic assessment of knowledge construction, reasoning adjustment, and teamwork processes. Second, given the high complexity of mechanical design projects, teachers—constrained by teacher-student ratios, teaching resources, and time—struggle to provide sustained individualized guidance, leaving some students to "minimally complete" tasks without deep exploration. These issues weaken the full educational potential of PBL in Mechanical Design.

3. Practice of the AIGC-Assisted PBL Teaching Model

3.1. Teaching Objective

In traditional teaching, teaching objectives focused mainly on knowledge instruction, skill development, and literacy cultivation. With the rapid development of AIGC, teaching objectives require expansion and restructuring.

Knowledge objectives: Beyond mastering design theories, component design methods, and standards, students are expected to understand AIGC principles and applications. They should be able to use AIGC for knowledge retrieval, rapid access to engineering data, and multi-scheme validation. For example, by engaging with AIGC, students can generate and compare conceptual designs, deepening their understanding of design principles and engineering trade-offs.

Ability objectives: AIGC reshapes student competence structures. Beyond traditional skills such as design calculation, data retrieval, and engineering expression, new objectives emphasize creativity, iterative optimization, and intelligent communication under human–AI collaboration. Students can use AIGC for parametric design and rapid modeling to shorten design cycles, and leverage AI-generated visualization and documentation to improve communication. Crucially, students must critically evaluate and refine AI outputs, transitioning from "tool users" to "intelligent collaborators."

Literacy objectives: The introduction of AIGC further underscores engineering ethics and academic norms. Students should recognize that engineers remain the ultimate responsible party in design, enhancing their sense of responsibility. They must respect academic integrity and intellectual property, properly citing and responsibly using AI-generated content. Additionally, they should develop reflective thinking and data literacy to address potential biases and uncertainties in AI, and cultivate lifelong learning and adaptability to remain competitive amid technological change.

In summary, teaching objectives in Mechanical Design under AIGC exhibit a new "three-

dimensional integration": knowledge expanded by AI empowerment, abilities centered on human–AI collaboration and critical thinking, and literacy highlighting responsibility and continuous learning. This objective system not only adapts to technological trends but also lays a solid foundation for training "intelligent design conductors."

3.2. Construction of an AIGC-Assisted PBL Model

To address issues in traditional PBL such as result-orientation, lack of process evaluation, and resource constraints, this study proposes a hybrid "AI-assisted + project-driven" teaching model, constructed across four dimensions:

(1) Cognitive support at the starting stage: AIGC helps students quickly grasp key knowledge points and learning essentials. Using structured prompts (e.g., "Who am I + What do I need to do + Constraints + Expected results"), AI generates targeted cases and resources, enabling students to build clear frameworks and preliminary design ideas before project initiation.

(2) Human–AI collaboration: During project development, AIGC provides diversified solutions, parameter suggestions, and logical validations for rapid iteration and optimization. Students critically evaluate AI outputs through group discussions, peer review, and teacher feedback, transitioning from "executors" to "intelligent collaborators." This enhances traditional design skills while strengthening systemic decision-making in complex contexts.

(3) Expanded multidimensional process evaluation: A process-oriented evaluation system is constructed with teacher assessments, inter-group peer reviews, and intra-group self-assessments, covering classroom performance, individual contributions, and project iterations. Teachers can also employ AIGC to generate open-ended exam questions, challenging students to demonstrate creativity and integrated application in open scenarios.

(4) Intelligent ecosystem support: AIGC provides teachers with personalized learning pathways and data-driven feedback, alleviating guidance pressure due to high student–teacher ratios. This enables teachers to focus more on value-oriented guidance and deep inquiry.

In sum, the AIGC-assisted PBL model addresses core challenges of traditional PBL while upgrading course objectives: expanding knowledge boundaries, strengthening collaboration and critical thinking, and reinforcing responsibility and academic integrity.

3.3. Teaching Process Design

The integration of AIGC reshapes the teaching process into a closed-loop "preparation—exploration—extension—application" path across four stages:

(1) Pre-class preparation: Students use AIGC tools for intelligent Q&A and knowledge graphs to grasp key concepts (e.g., gear strength, shaft design principles). Teachers provide AI-generated mind maps, case studies, and visualizations to help students build knowledge frameworks.

(2) In-class teaching: Teachers remain the central facilitators, while AIGC serves as an "intelligent assistant." Teachers use AI to present multiple design options and demonstrate parameter impacts; students employ AIGC to generate design ideas or models, followed by critical evaluation and refinement in group discussions. Class time thus emphasizes teamwork, iteration, and decision-making.

(3) After-class assignments and discussions: Assignments shift toward open-ended and exploratory tasks. Teachers employ AIGC to create diverse problem sets (e.g., parametric variations, case improvements, interdisciplinary tasks). Students may use AI for initial drafts or refinements but must revise critically. Online platforms with AI feedback mechanisms strengthen student–student interaction and reflection.

(4) Group projects: As the central practice component, group projects leverage AIGC for rapid

idea generation, parametric modeling, material selection, and strength checks. Teachers conduct dynamic evaluations based on performance, contribution, and iteration, supplemented by peer- and self-assessments. Final assessments combine project presentations with AI-assisted open-ended exams to raise challenge and innovation.

4. Teaching Practice Outcomes

The use of AIGC significantly improved students' understanding of complex concepts and design principles. AI-generated knowledge graphs, case demonstrations, and visualizations helped students grasp relationships and parameter effects. Literature integration in reports improved in both quantity and quality. Surveys indicated most students found AIGC reduced difficulty and improved efficiency, though some showed overreliance, resulting in weak mastery of fundamentals.

AIGC enhanced design efficiency and iteration capabilities. Students generated preliminary designs rapidly and refined them through parameter validation, shortening project cycles. Compared to previous cohorts, current students achieved higher project completion and design rationality. Some groups extended analysis to economics and manufacturability, showing interdisciplinary competence. Presentations improved with AI-assisted visualization, though some students accepted AI outputs uncritically, underscoring the need to strengthen critical thinking.

Reform highlighted teamwork and academic norms. Through teacher assessment, collaborative task allocation within groups, and intra-group self-evaluation, students' sense of responsibility and teamwork spirit have significantly improved. Teachers required explicit acknowledgment of AIGC-generated content, raising awareness of integrity and intellectual property. Some students actively reflected on AI limitations and proposed improvements, demonstrating critical and reflective thinking. Overall, professional ethics and lifelong learning awareness were strengthened, though differences across groups remained, requiring further balance through case-based training.

The AIGC-assisted PBL model alleviated pain points such as high project difficulty and weak process support, significantly improving student interest, design ability, and literacy. However, issues such as insufficient critical thinking, unclear teacher–AI role boundaries, and the need for stable evaluation frameworks remain. Future work should optimize teacher–AI collaboration and emphasize the "AI as assistance, not substitution" principle.

5. Conclusions

Throughout this process, students not only achieved significant improvement in knowledge breadth and depth but also expanded their abilities and perspectives. Both teachers and students enhanced their digital literacy. Based on the present practice, this study summarizes the AIGC-assisted PBL model for Mechanical Design, proposes reference criteria for selecting AI tools, and discusses issues encountered. These reflections are expected to inform future exploration and application of generative AI in emerging engineering curricula.

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