

PBL Teaching Transformation Based on AI Collaborative Education: A Two-Way Reconstruction Path of Teacher Roles and Student Abilities

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Abstract: This paper focuses on the transformation of the project-based learning (PBL) teaching model driven by artificial intelligence (AI), and explores the two-way reconstruction path of teacher roles and student abilities. Combining metacognitive theory to analyze the pain points of traditional PBL, this paper systematically sorts out the functional reconstruction path of AI in the dimensions of teaching design, process monitoring, and evaluation feedback. Then, starting from the social role theory, this paper deeply analyzes the transformation of teacher identity and the reconstruction of student abilities in the AI-PBL fusion scenario. AI not only reshapes the logic of cultivating students' abilities but also prompts teachers to achieve deep changes in their roles at the cognitive, relational, and ethical levels. Human-machine collaboration should not replace teachers' emotional values and educational judgments, but should become a key support for optimizing the educational ecology and realizing personalized education.

Keywords: Artificial intelligence; Project-based learning; Teacher role; Student ability; Collaborative education

Online publication: December 5, 2025

1. Introduction

Artificial intelligence (AI) intelligent tools such as ChatGPT are reshaping the educational ecosystem, providing unprecedented support for education^[1] and putting forward new requirements for the role of teachers^[2,3]. Project-based learning (PBL) cultivates students' key abilities through real-life problems and projects. However, the widespread penetration of AI has raised concerns about teacher autonomy, student participation, and ethical considerations of algorithmic decision-making^[3]. This highlights the urgency of AI's coordinated reconstruction of PBL teaching, teacher roles, and student abilities.

Existing research has revealed that AI can help improve students' motivation, performance, and problem-solving ability^[4], but there is still a need to systematically explore the transformation of teachers' roles and the reconstruction of students' abilities in the AI-PBL environment. This study focuses on this synergy mechanism and provides theoretical support and practical guidance for promoting innovative changes in the way of

educating people in the intelligent era.

2. Functional reconstruction of problem-oriented AI-PBL teaching transformation

AI collaborative education refers to a new educational paradigm in which AI technology and educational subjects form a dynamic symbiotic relationship. Its core is to optimize the learning process and results through human-computer collaboration^[5]. **Figure 1** summarizes the dilemma of traditional PBL teaching and the functional reconstruction mechanism of AI empowerment to achieve value goals. AI not only provides technical support in intelligent project generation, behavior analysis, path planning, etc., but also achieves a value leap in promoting precise teaching, system evaluation, and literacy development.

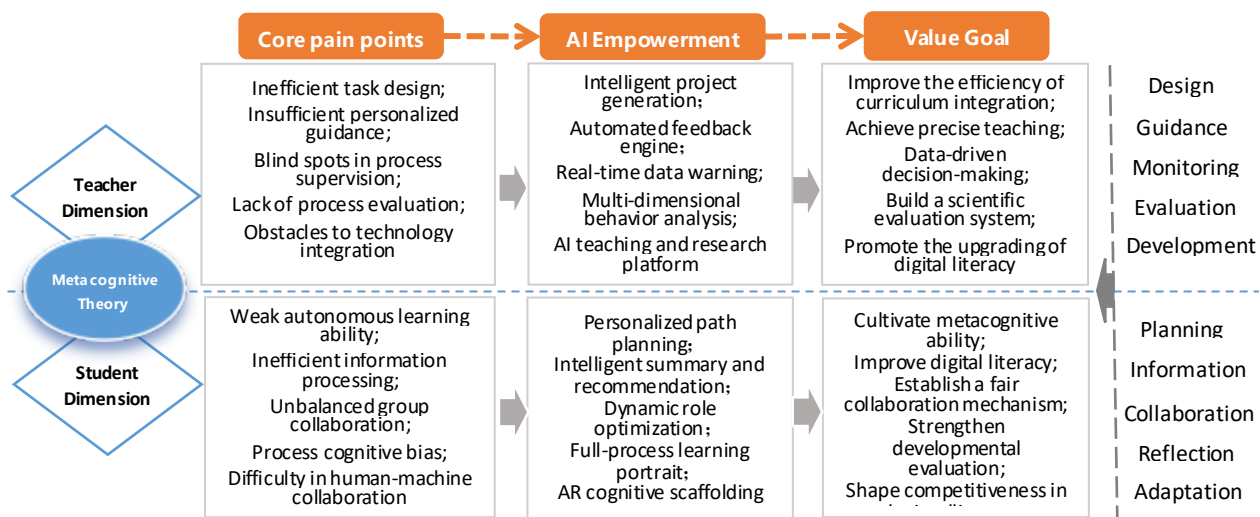


Figure 1. AI-PBL teaching transformation framework

3. Paths to reconstruct the teacher role based on AI collaborative education

Social role theory emphasizes that individuals perform their duties within a series of role expectations given by society. In the AI-BPL context, the role relationship of teachers is undergoing an essential reconstruction from one-way authority to a multi-dimensional hub, forming a five-dimensional dynamic network with teachers as the hub (**Figure 2**)

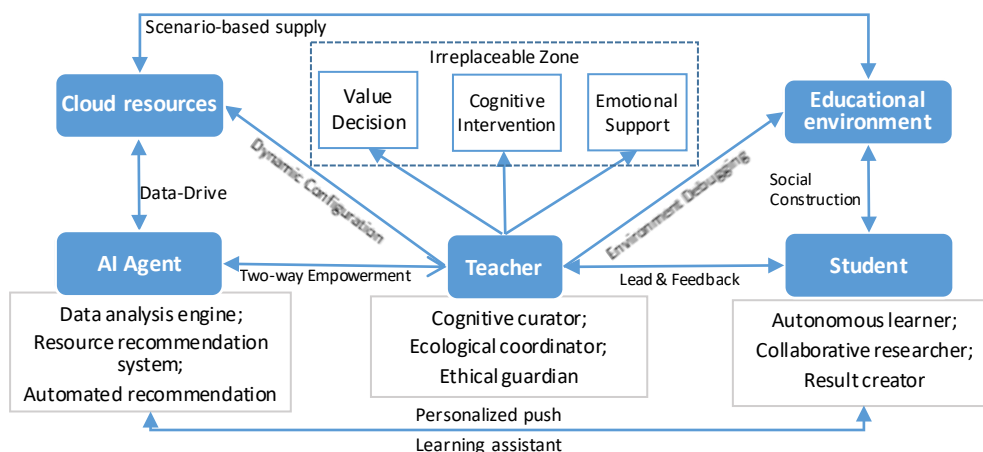


Figure 2. Teacher role relationship

3.1. Cognitive dimension: From knowledge authority to cognitive curator

Teaching supported by AI, students can actively construct knowledge with the help of AI tools, autonomous search, and interdisciplinary collaboration, which promotes the transformation of teachers' roles from "knowledge monopolists" to "cognitive curators" and "thinking development teachers." The core task of teachers is to screen, organize, and reconstruct learning resources from massive information, design learning paths that support students' cognitive development, and guide students to improve their critical thinking, systematic analysis, and transfer capabilities in task-driven learning ^[6]. This transformation is in line with the constructivist teaching concept of "cognitive conflict." Compared with traditional PBL, AI-generated problem situations can better stimulate students' metacognitive awareness and deep participation.

3.2. Relational dimension: From classroom controller to ecological coordinator

AI is increasingly embedded in educational scenarios, requiring teachers to take on multiple responsibilities such as organization, coordination, and emotional support between technology, students, content, and real problems in order to maintain the dynamic balance and multi-faceted collaboration of the learning system. Teachers not only need to play an active role in group role allocation, task rhythm management, and conflict mediation, but also need to gain insights into students' collaborative participation behaviors based on AI-generated data and dynamically adjust team structures and support methods ^[7]. This transformation not only involves the renewal of teaching methods but also reflects the evolution of teachers' social identity structure, emphasizing the enhancement of connections and support between teachers and between teachers and students through shared responsibility, collaborative decision-making, and professional cooperation, thereby improving the innovation and adaptability of the education system.

3.3. Ethical dimension: From technology user to ethical leader

Teachers should actively integrate ethical issues into learning tasks, guide students to explore in depth practical issues such as "whether AI-generated content constitutes plagiarism," and use technology participation as an opportunity to stimulate their critical thinking on public values such as fairness, responsibility, and justice. This situation-based ethical discussion helps students develop critical AI literacy and social responsibility, and also strengthens the responsibilities of teachers. At the same time, teachers must have a keen sense of data ethics, clearly define privacy boundaries and technology usage standards, and prevent educational technology from inadvertently infringing on students' right to know and autonomy.

4. Reconstruction of student abilities under the AI-PBL teaching model

4.1. Knowledge construction ability: From passive acceptance to active generation

Students need to have more proactive, critical, comprehensive, and iterative knowledge construction capabilities. The first is the ability to create independently, and to continuously modify, supplement, and reconstruct knowledge content through interaction with AI ^[8]. Through the co-creation process, students' active learning awareness and academic expression ability are enhanced; the second is the ability to integrate information from a single medium to multiple data coordination, requiring students to integrate multiple information resources such as images, data, voice, and text in the process of project promotion to construct a richer and more comprehensive knowledge model. Finally, critical and reflective cognition emphasizes that students should not only be able to "use AI," but also be able to "question AI," have basic information criticism literacy, and the ability to reflectively evaluate AI output.

4.2. Collaborative capabilities: From task division to human-machine co-creation

AI participates in the student team collaboration process as a “virtual collaborator.” Students need to understand AI’s logical rules, input and output methods, as well as higher-level collaborative adjustment capabilities and team ethics awareness. Collaboration is not only a work allocation supported by technology, but also a deep interactive process across the boundaries of man and machine, which promotes students to form the collaborative awareness, process management, and co-creation capabilities required in the digital age.

4.3. Metacognitive ability: From process reflection to strategy regulation

Metacognitive ability refers to the learner’s ability to monitor and regulate their own cognitive activities, which is an important foundation for efficient learning. The AI-PBL teaching model provides instant feedback and process data tracking capabilities, allowing students to reflect on their decisions, strategies, and understanding levels in real time during the learning process. In addition, students need to improve their metacognitive awareness of AI regulation, judge the applicability of AI-generated content, and judge whether the prompts used are effective, etc. This “second-order metacognition” expands the boundaries of traditional metacognition and becomes the core driving force for the continuous optimization of generative tasks and the deep construction of knowledge.

4.4. Information literacy: From the use of search tools to AI content analysis

In addition to the information retrieval and tool use capabilities in traditional PBL, students must also develop the ability to identify information sources, potential biases, and inference generation mechanisms, and the attribution of AI-generated content. In addition, information literacy is no longer an individual behavior, but the ability to dynamically negotiate in the process of group collaboration and AI interaction. Students need to jointly define which information can be trusted and which needs further verification, and promote the formation of information ethics literacy in the AI era with credibility, transparency and responsibility as the core.

5. Implementation strategy of bidirectional reconstruction under the AI-PBL model

5.1. Content design: Building a task-driven knowledge generation field

In the context of AI collaborative education, curriculum design should break through the shallow cooperation model of “task is division of labor” in traditional PBL, strengthen the authenticity, complexity, and multimodality of problems, and guide students to carry out generative learning with the support of AI. Redesign the course units around the ternary structure of “core literacy-real situation-AI collaboration.” Embed clear nodes and goals for the use of AI, such as using large models such as DeepSeek to sort out opinions, using text generation tools to assist in writing report summaries, and using visual AI analysis tools to display data.

5.2. Teaching organization: Creating a three-way collaborative task execution ecosystem

AI-PBL teaching requires not only efficient collaboration between teachers and students, but also the embedding of AI into the teaching interaction chain to form a three-way symbiotic mechanism of “teacher-student-AI.” Teachers are no longer task distributors and process supervisors, but planners and schedulers of the AI collaborative platform. In teaching, an “AI task assistance role” can be set up to establish a dynamic feedback mechanism. Through the AI platform, data such as student submission results, interaction frequency, and AI usage behavior are collected in real time. Teachers can adjust the task difficulty and optimize the grouping

structure based on the data to build a highly responsive teaching organization system.

5.3. Learning support: Building a data-driven precision service system

AI's diagnostic and predictive capabilities can provide personalized content and feedback for students with different learning styles and ability levels. For example, if students encounter difficulties during a task, they can call on the AI model for content assistance; in data processing tasks, AI can be used for data modeling and analysis to improve students' operational efficiency and comprehension. Teachers can use AI to grasp students' participation status, content generation quality, collaboration frequency, etc., in real time, and implement precise data-based teaching interventions. It is necessary to establish a "data literacy improvement mechanism" for teachers and enhance teachers' ability to analyze and interpret AI feedback through school-based training, practical training, and other methods to achieve digital teaching support.

5.4. Ethical safeguards: Implementing norms and value guidance for the use of AI

AI-generated content has risks such as fuzzy originality, value bias, and data leakage, which must be systematically prevented and controlled at the institutional level. Schools should formulate ethical use standards for AI teaching platforms, clarify the boundaries of students' use of AI (such as assistance rather than replacement), the division of responsibilities for the ownership of results, and the scope of data use, and build a "knowable, controllable, and accountable" ethical framework. In the teaching process, teachers should actively set up AI ethics discussion modules to guide students to think about the boundaries between technology and humanities, cultivate ethical judgment and sense of responsibility in the AI era, strengthen the people-oriented value background in education, and truly realize the original return of AI technology to serve the original intention of education.

6. Conclusion

Under the AI-PBL teaching model, teachers transform from knowledge transmitters to cognitive curators, relationship coordinators, and ethical guardians, while students grow from knowledge recipients to problem solvers with the support of AI. AI-driven PBL expands the learning space and teaching boundaries, and promotes the transformation of education towards fairness, personalization, and intelligence. This change is not only the superposition of technology, but also about the comprehensive reconstruction of educational concepts, teacher development, ethical norms, and system mechanisms. In order to meet the challenges of the integration of AI and education, it is urgent to build a forward-looking theoretical framework and practical path to promote the transition from "AI + education" to "AI collaborative education" and consolidate the future education ecology that is people-oriented and collaborative.

Funding

The 2023 Jilin Provincial Department of Education Science and Technology (Social Sciences) Research Planning Project "Research on the Organizational Models of Private Universities in Promoting Rural Revitalization in Jilin Province" (JJKH20231426SK)

Disclosure statement

The authors declare no conflict of interest.

References

- [1] Holmes W, Bialik M, Fadel C, 2019, Artificial Intelligence in Education Promises and Implications for Teaching and Learning, Center for Curriculum Redesign.
- [2] Zawacki-Richter O, Marin VI, Bond M, et al., 2019, Systematic Review of Research on Artificial Intelligence Applications in Higher Education—Where Are the Educators? *International Journal of Educational Technology in Higher Education*, 16(1): 1–27.
- [3] Zhai X, 2022, The Human-AI Partnership in Education: A Future-Oriented Perspective. *Educational Review*, 74(1): 1–20.
- [4] Kolmos A, Holgaard JE, Clausen NR, 2021, Progression of Student Self-Assessed Learning Outcomes in Systemic PBL. *European Journal of Engineering Education*, 46(1): 67–89.
- [5] Pedro F, Subosa M, Rivas A, et al., 2019, Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development, UNESCO.
- [6] Zha S, Qiao Y, Hu Q, et al., 2024, Designing Child-Centric AI Learning Environments: Insights from LLM-Enhanced Creative Project-Based Learning. *arXiv*. <https://doi.org/10.48550/arXiv.2403.16159>
- [7] Ravi P, Masla J, Kakoti G, et al., 2025, Co-Designing Large Language Model Tools for Project-Based Learning with K12 Educators, *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, 1–25.
- [8] Lee E, 2024, The Impact of Generative AI Chatbots on University Writing PBL Classes. *The Journal of General Education*, (29): 7–54.

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