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AI-Supported Project-Based Learning Reform for the Data Structures Course under the "Less Teaching, More Learning" Philosophy

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Abstract: This study proposes an AI-supported project-based learning (PBL) framework for the Data Structures course under the Less Teaching, More Learning philosophy. The traditional chapter-based curriculum was reconstructed into eight authentic Python projects supported by the learning activity management system and a large language model-based AI teaching assistant. A controlled teaching experiment involving two undergraduate classes was conducted to evaluate the effectiveness of the proposed approach. The results indicate that the AI-supported PBL model significantly improved students' academic performance, programming competence, and self-directed learning compared with conventional instruction. The proposed framework provides a practical and transferable paradigm for AI-enabled curriculum reform in computer science education.

Keywords: Project-based learning; Less Teaching, More Learning; Learning activity management system; Intelligent teaching assistant; Data structures

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1. Introduction

The rapid development of generative artificial intelligence (AI), particularly large language models (LLMs), is reshaping higher education by transforming traditional knowledge transmission into intelligent learning support [3]. Recent studies have shown that AI technologies provide effective support for knowledge acquisition, programming assistance, and personalized learning, creating new opportunities for educational innovation [4,7]. Meanwhile, project-based learning (PBL) has been widely recognized as an effective learner-centered pedagogy that develops students' problem-solving ability, engineering competence, and collaborative learning through authentic projects [1]. The integration of AI with PBL therefore provides a promising direction for curriculum reform in computer science education.

Data Structures is a core foundational course for computer science and data science majors. It covers

essential topics including linear lists, stacks, queues, trees, graphs, searching, and sorting algorithms, which form the theoretical foundation for subsequent professional courses. However, traditional instruction is still organized around textbook chapters and mainly follows a "lecture–exercise–assessment" model. Although students are able to understand individual concepts, they often encounter difficulties in integrating knowledge and applying appropriate data structures and algorithms to authentic engineering problems.

The Less Teaching, More Learning (LTML) philosophy advocates shifting teachers from knowledge transmitters to learning designers and facilitators, encouraging students to actively construct knowledge through inquiry and practice. The learning activity management system (LAMS) provides an effective platform for organizing learning activities, collaborative discussion, project implementation, and formative assessment [2]. Furthermore, recent studies have demonstrated that AI teaching assistants supported by large language models and retrieval-augmented generation (RAG) can provide contextual question answering, programming guidance, and personalized feedback throughout the learning process [5,6]. At the same time, researchers have emphasized that AI should function as a learning facilitator rather than a replacement for teachers in order to ensure educational quality and academic integrity [8]. Nevertheless, few studies have systematically integrated LTML, LAMS, AI teaching assistants, and project-based learning into a unified curriculum reform framework for computer science education.

Therefore, this study proposes an AI-supported Project-Based Learning (AI-PBL) framework for the Data Structures course under the LTML philosophy. By reconstructing the traditional chapter-based curriculum into eight authentic Python projects and integrating LAMS with an AI teaching assistant, this study aims to improve students' knowledge construction, programming competence, and self-directed learning, providing a practical reference for AI-enabled curriculum reform in computer science education.

To evaluate the effectiveness of the proposed framework, this study addresses the following research questions:

RQ1: Can AI-supported Project-Based Learning improve students' learning outcomes in the Data Structures course?

RQ2: Can the Learning Activity Management System (LAMS) effectively support project-based learning activities throughout the teaching process?

RQ3: Can an LLM-based AI teaching assistant enhance students' programming competence and self-directed learning?

The remainder of this paper is organized as follows. Section 2 analyzes the current problems in the Data Structures course. Section 3 presents the proposed AI-supported Project-Based Learning reform framework. Section 4 describes the teaching practice. Section 5 evaluates the teaching effectiveness through a controlled experiment. Finally, Section 6 concludes the paper and discusses future work.

2. Current Problems in the Data Structures Course

Data Structures is a core foundational course for computer science majors, aiming to cultivate students' abilities in data organization, algorithm design, and computational thinking. However, the traditional curriculum is still organized around textbook chapters. This approach often results in fragmented knowledge, limited connections between theoretical concepts and authentic engineering applications, passive student participation, and an assessment system that emphasizes examination performance rather than practical competence. Consequently, students frequently experience difficulties in applying data structures and

algorithms to solve real-world programming problems. To address these challenges, an instructional model that combines the Less Teaching, More Learning (LTML) philosophy, the Learning Activity Management System (LAMS), Project-Based Learning (PBL), and AI teaching assistants is proposed. This integrated framework shifts learning from chapter-based instruction to authentic project-driven practice while providing continuous learning support throughout the teaching process.

3. AI-supported project-based learning reform framework

3.1. Reform philosophy of "Less Teaching, More Learning"

Traditional chapter-based instruction often emphasizes knowledge delivery rather than students' ability to solve authentic engineering problems. To address this limitation, this study adopts the Less Teaching, More Learning (LTML) philosophy and Project-Based Learning (PBL) as the guiding principles for curriculum reform. Instead of passively receiving knowledge, students actively construct understanding through project exploration, collaborative discussion, and programming practice, while teachers shift from knowledge transmitters to learning designers and facilitators. Based on this learner-centered philosophy, an AI-supported Project-Based Learning (AI-PBL) framework is proposed to support continuous learning throughout the course.

3.2. Curriculum reconstruction and implementation

The proposed AI-supported Project-Based Learning (AI-PBL) model was implemented during the 2025 autumn semester in the Data Structures course for undergraduate students majoring in Data Science. The experimental class adopted the AI-supported PBL model under the Less Teaching, More Learning (LTML) philosophy, while the control class followed conventional chapter-based instruction. Both classes were taught by the same instructor using the same textbook, teaching schedule, assessment criteria, and final examination, ensuring that the teaching model was the only experimental variable.

Rather than delivering isolated theoretical knowledge, the reformed course reconstructed the entire curriculum into eight authentic engineering projects. Students completed Python programming tasks progressively while learning data structures and algorithms through project implementation. LAMS organized classroom activities, collaborative learning, and formative assessment, whereas the AI teaching assistant supported students before and after class by providing knowledge previews, programming guidance, code diagnosis, and personalized learning reports. The mapping between the eight projects and learning objectives is presented in **Table 1**.

Table 1. Eight projects and learning design

Project	Learning objectives	Python programming	Assessment
Project 1 Intelligent Library Management	Understand data structure, algorithms, complexity	Implement list-based book management	Programming + Reflection
Project 2 Customer Information Management	Sequential list and linked list	Customer CRUD operations	Programming + Evaluation
Project 3 Smart Banking System	Stack and Queue	Queue simulation and scheduling	Project + Quiz
Project 4 Gene Data Analysis	String and Array	DNA sequence processing	Programming Practice
Project 5 Smart Campus OA	Tree Structures	Organization hierarchy management	Project Assessment

Project 6 Smart City Navigation	Graph Algorithms	Graph traversal and shortest path	Programming + Report
Project 7 Intelligent Search Platform	Search Algorithms	Hash, BST, AVL implementation	Project Demonstration
Project 8 E-commerce Ranking	Sorting Algorithms	Multi-strategy sorting system	Comprehensive Project

3.3. LAMS-supported and AI-assisted teaching process

Traditional classroom instruction is mainly organized around teacher lectures, providing limited opportunities for students to engage in active learning and continuous reflection. To promote learner-centered education under the Less Teaching, More Learning (LTML) philosophy, this study adopts the Learning Activity Management System (LAMS) to organize the entire teaching process rather than simply delivering course content. LAMS structures learning activities into a progressive workflow (**Figure 1**). This process encourages students to learn through project exploration, collaborative discussion, programming practice, and reflective learning, thereby supporting continuous knowledge construction.

The AI teaching assistant complements rather than replaces classroom instruction. Before class, it supports students in previewing prerequisite knowledge and answering conceptual questions. During class, students complete project tasks collaboratively under the guidance of LAMS, while the teacher organizes discussion and programming activities. The AI assistant intentionally withdraws from the core classroom process to ensure that knowledge is constructed through interaction and practice instead of direct AI-generated solutions. After class, the AI tutor resumes its role by providing programming hints, code diagnosis, learning reports, and personalized feedback to facilitate independent review and reflection. Throughout the course, teachers remain responsible for project design, classroom organization, assessment, and final evaluation, ensuring instructional quality and academic integrity.

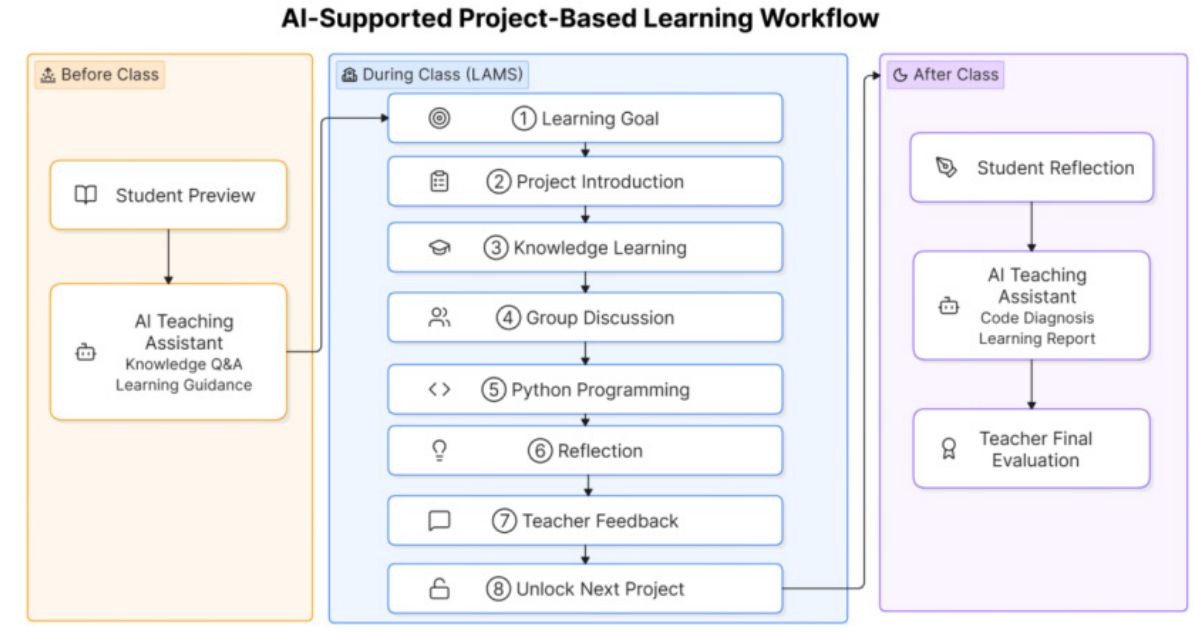

Figure 1. Overall AI-supported Project-Based Learning Workflow Based on LAMS

4. Teaching evaluation and reform outcomes

To evaluate the effectiveness of the proposed AI-PBL model, a controlled teaching experiment was conducted involving two undergraduate Data Structures classes. The experimental class adopted the AI-PBL model based on LAMS, whereas the control class followed conventional chapter-based instruction. Both classes used the same instructor, textbook, teaching hours, assessment criteria, and final examination to ensure that the teaching model was the only experimental variable.

The teaching effectiveness was evaluated using multiple indicators, including final examination scores, project performance, teacher assessment, and student course evaluation. Statistical analysis indicated that the experimental class achieved significantly better learning outcomes than the control class ($P < 0.05$). Students demonstrated higher programming competence, stronger knowledge integration, and improved self-directed learning abilities. Furthermore, course evaluation results showed greater student satisfaction with project learning, classroom interaction, and AI-assisted learning support.

It should be noted that the AI-generated learning reports and competency profiles were used solely as formative feedback and were not included in the final course grades. Final assessment remained the responsibility of instructors to ensure fairness, instructional quality, and academic integrity. Overall, the results demonstrate that integrating LAMS, authentic projects, and AI teaching assistants effectively enhances both learning performance and student engagement in the Data Structures course.

5. Conclusion and future work

5.1. Contributions

This study proposed an AI-PBL framework for the Data Structures course under the Less Teaching, More Learning philosophy. By integrating LAMS, eight authentic Python projects, and an LLM-based AI teaching assistant, the traditional chapter-based curriculum was transformed into a project-oriented learning model. The controlled experiment demonstrated that the proposed approach effectively improved students' learning performance and programming competence.

5.2. Educational implications

The proposed framework provides a practical paradigm for integrating AI into computer science education. Rather than replacing teachers, AI functions as a learning facilitator, while LAMS organizes project activities and formative assessment, jointly supporting learner-centered teaching and sustainable curriculum reform.

5.3. Limitations and future work

This study was conducted in one course over one semester. Future work will incorporate lightweight RAG-based knowledge retrieval, learning analytics, and multi-course validation to further enhance the scalability and effectiveness of the proposed framework.

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Disclosure statement

The authors declare no conflict of interest.

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