Research on the Curriculum Construction Model of In-Depth Integration of AI and Project-Based Learning under the Background of Smart Education

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Abstract: With the in-depth advancement of smart education, the integration of artificial intelligence (AI) technology and project-based learning (PBL) has become an important direction of curriculum reform. By sorting out the research progress at home and abroad, this paper clarifies the connotation and characteristics of smart education, compares its differences from traditional digital education, analyzes the needs and pain points of curriculum construction combined with practical cases, and finally constructs a "goal-content-implementation-evaluation" four-dimensional integrated curriculum construction model. This study provides theoretical support and practical paths for the in-depth integration of AI and project-based learning under the background of smart education.

Keywords: Smart Education; Artificial Intelligence (AI); Project-Based Learning (PBL); Curriculum Construction Model; Four-dimensional Integration

1. Introduction

Driven by the dual impetus of the digital economy and the digital transformation of education, smart education has emerged as a core engine for promoting the high-quality development of education. Artificial Intelligence (AI) technology, leveraging its advantages in data processing, personalized recommendation, and intelligent interaction, provides technical support for innovations in teaching and learning. Meanwhile, Project-Based Learning (PBL), centered on problem orientation, practice-driven approaches, and competency development, serves as a crucial teaching model for implementing core literacy cultivation. The in-depth integration of the two not only addresses the limitations of traditional PBL, such as insufficient personalized guidance, difficulties in process management, and a single evaluation dimension, but also expands the application boundaries of AI technology in educational scenarios. It holds significant importance for reconstructing curriculum systems and innovating teaching methods. Currently, relevant explorations have been conducted both domestically and internationally[1]; however, challenges remain, including unclear integration mechanisms, fragmented practical models, and weak theoretical support. Against this backdrop, this paper conducts research from four dimensions—systematization of research progress, analysis of theoretical foundations, identification of practical pain points, and model construction—aiming to develop a replicable and promotable curriculum construction model that provides references for curriculum reform in universities under the context of smart education[2].

2. Research Progress on Curriculum Construction: In-Depth Integration of AI and PBL Under the Background of Smart Education

2.1 International Progress in Curriculum Construction for the Integration of AI and Project-Based Learning

International research on the integration of AI and Project-Based Learning (PBL) has an earlier start, focusing on two core pillars: technology empowerment and student-centeredness[3]. The AI-PBL learning platform developed by the Educational Technology Laboratory at Stanford University in the United States uses intelligent algorithms to analyze students' project progress, pushing real-time resources and guidance suggestions to achieve dynamic management and control of the project process. In Finland's "phenomenon-based teaching" reform, AI tools are integrated to support students in conducting inquiry-based learning around interdisciplinary projects, which has significantly improved their innovative and collaborative abilities. Additionally, international research emphasizes evidence-based practice, verifying the integration effects through long-term tracking data[4]. For example, a 2023 study published in the Journal of Educational Technology & Society showed that the application of the AI+PBL model in STEM disciplines increased students' problem-solving ability scores by 32% and learning engagement by 28% compared with traditional teaching[5]. However, most international studies focus on single-discipline applications or technical implementations, lacking the systematic construction of an overall curriculum construction model.

2.2 Domestic Progress in Curriculum Construction for the Integration of AI and Project-Based Learning

Domestic research is policy-driven. With the issuance of policies such as the Action Plan for Educational Informatization2.0 and the Guidelines for the Construction of Smart Education Platforms, research on the integration of AI and PBL has advanced rapidly. Current research mainly focuses on three aspects: First, at the technical application level, it primarily involves using AI homework grading systems and virtual simulation experiment platforms to assist in the implementation of PBL[6]. Second, in terms of disciplinary practice, pilot integrations have been carried out in subjects such as mathematics, information technology, and science, forming teaching processes for the integration of AI and PBL. Third, at the evaluation reform level, many universities are exploring the use of AI to achieve multi-dimensional automatic evaluation of project outcomes[7]. While certain achievements have been made in the integration methods of AI and PBL, several limitations remain: First, theoretical research lags behind practice, with a lack of systematic research on integration mechanisms and core elements of curriculum construction. Second, practical cases focus on individual breakthroughs, and systematic and structured applications are insufficient.

3. Theoretical Foundations of Curriculum Construction for the In-Depth Integration of AI and Project-Based Learning Under the Background of Smart Education

3.1 Connotation and Characteristics of Smart Education

Smart education is an educational form that takes the cultivation of wisdom literacy as its core, relying on technologies such as AI, big data, and the Internet of Things (IoT) to construct a personalized, intelligent, and contextualized learning ecosystem. Its core characteristics are mainly reflected in four aspects: personalized adaptation, contextual construction, collaborative development, and intelligent management and control. Personalized adaptation refers to the use of AI to analyze students' learning data and accurately match learning resources and teaching strategies[8]. Contextual construction utilizes technologies such as virtual simulation and augmented reality (AR) to create real project scenarios, promoting the transfer and application of knowledge. Collaborative development involves building a cross-temporal and cross-spatial collaboration platform to support real-time interaction and resource sharing between teachers and students, as well as among students. Intelligent management and control primarily realize dynamic monitoring, early warning of problems, and effect evaluation of the teaching process through AI intelligent platforms[8].

3.2 Comparative Study of Smart Education and Traditional Digital Education

The differences between smart education and traditional digital education are mainly reflected in three aspects: First, the technical positioning is different. Traditional digital education is centered on technical assistance, serving as a tool for knowledge transmission through technical means such as PPT. In contrast, smart education is centered on technical empowerment, mainly applying AI technology to the entire teaching process. In addition to knowledge dissemination, it can also support curriculum design, curriculum evaluation, and other links[9]. Second, the presented teaching logic is different. The main teaching logic of traditional digital education emphasizes teacher-centered knowledge dissemination, while smart education follows a student-centered competency development logic. Through the integration of AI and PBL, students can be guided to actively explore and solve real-world problems. Third, the evaluation methods are different. Traditional digital education emphasizes result-oriented evaluation based on the degree of knowledge mastery, while smart education adopts process-oriented evaluation based on process data such as students' enthusiasm for participating in projects, collaboration, and innovation, which is more multi-dimensional and dynamic. The specific comparisons are shown in Table 1 below:

Table 1 Comparative Analysis of Smart Education and Traditional Digital Education

Comparative Dimensions	Traditional Digital Education	Smart Education
Technical Positioning	Centered on technical assistance; technology serves only as a tool for knowledge transmission, with application scenarios limited to resource presentation and simple interaction, and no in-depth involvement in teaching process design and decision-making.	Centered on technical empowerment; technologies such as AI and big data are deeply integrated into the entire process of curriculum design-teaching implementation-process management and control-evaluation and feedback, becoming a key support for promoting the innovation of teaching models.
Teaching Logic	Follows the logic of knowledge transmission, with a teacher-centered approach. The teaching process presents a linear model of teacher lecture, student reception, and exercise consolidation. Students are in a passive learning state, lacking exploration and practice of real-world problems.	Follows the logic of competency cultivation, with a student-centered approach. Relying on the integration of AI and PBL, it constructs a non-linear model driven by real-world problems, featuring group collaborative inquiry, AI-assisted guidance, and iterative optimization of achievements. It focuses on the active development of students' innovative and collaborative abilities.
Evaluation Methods	Result-oriented evaluation with a single dimension, focusing on students' mastery of knowledge. Evaluation data relies on manual collection, lacking dynamic tracking of learning processes and competency performance.	Process-oriented evaluation as the main approach, constructing a mixed evaluation system of AI + manual assessment. It adopts multiple evaluation dimensions: AI collects process data such as project progress, collaborative contribution, and tool application capabilities, while teachers provide subjective evaluations of the innovation and feasibility of achievements, realizing dynamic and comprehensive assessment.

3.3 Theoretical Support for the Curriculum Construction Model of AI and PBL Integration under the Background of Smart Education

From a theoretical perspective, the curriculum construction for the integration of AI and PBL under the background of smart education relies on three core theoretical foundations: constructivist learning theory, the Technology Acceptance Model (TAM), and the core literacy framework. Constructivism emphasizes that learning is an active process of knowledge construction. PBL provides students with a carrier for knowledge construction, while AI technology reduces the difficulty of construction through personalized guidance. The Technology Acceptance Model points out that perceived usefulness and perceived ease of use are key factors influencing technology application; thus, AI tools need to simplify operational processes and enhance their supporting value for project-based teaching. The core literacy framework clarifies the goals of curriculum construction, requiring the cultivation of students' core competencies such as innovative ability, collaborative ability, and digital literacy through integration. These three theories collectively constitute the theoretical support for the integration model, providing directional guidance for curriculum construction[10].

4. Demand and Pain Point Analysis of Curriculum Construction for the In-depth Integration of AI and Project-Based Learning Under the Background of Smart Education

4.1 Case Background

Taking the "Logistics" course at a private university as an example, this course began attempting the integration of AI and PBL in 2025. It adopted the "AI-empowered research project on regional fresh food logistics enterprises" as the core project and introduced AI tools to assist teaching. The course is offered to 60 first-year students majoring in Logistics

Management, who are divided into 12 project groups, with a teaching cycle of 16 weeks.

4.2 Curriculum Construction Demands

Based on feedback from teachers and students, the core demands of curriculum construction include: first, the demand for personalized guidance. Students face issues such as the application methods of AI tools during project design and require real-time, accurate guidance from AI; second, the demand for process management and control. Teachers struggle to track the project progress of each group, requiring AI systems to automatically monitor progress and alert risks; third, the demand for multi-dimensional evaluation. Traditional evaluation relies on teachers' subjective scoring, so AI is needed to realize comprehensive evaluation of process data, achievement quality, and competency performance; fourth, the demand for resource integration. Project-based teaching requires a large number of cases, tools, and literature resources, and AI platforms are expected to achieve intelligent matching and recommendation of resources.

4.3 Implementation Effects and Pain Points

In terms of implementation effects, the students' project completion rate and learning satisfaction have been improved. However, obvious pain points remain: first, insufficient technical adaptability. First-year students have no prior AI learning foundation, and some AI tools are not easy to operate. Students need to spend extra time learning, which instead increases their learning burden; second, teachers' competency gaps. Teachers lack comprehensive abilities in AI technology application and PBL design, making it difficult to effectively integrate the two; third, single evaluation dimension. AI evaluation still focuses on technical achievements, with insufficient assessment of soft skills such as collaborative ability and innovative thinking; fourth, fragmented resources. The resources pushed by AI platforms have low matching degree with project needs, leading to the problem of resource overload.

5. Construction of a Curriculum Construction Model for the In-depth Integration of AI and Project-Based Learning Under the Background of Smart Education

5.1 Construction Principles

To construct a curriculum construction model for the in-depth integration of AI and Project-Based Learning (PBL) under the background of smart education, the following principles must be followed: First, the goal-oriented principle. Focusing on the key training objectives of knowledge, abilities, core literacy, and ideological and political education, the direction of integration between AI and PBL is clearly defined. Second, the technology adaptability principle. When integrating AI tools, their use should not be pursued for the sake of technology itself; instead, AI tools that are easy to operate, compatible with the cognitive abilities of students at the corresponding academic stage, and aligned with teaching needs should be selected. Finally, the closed-loop iteration principle. Data recorded by AI intelligent platforms is analyzed to grasp students' learning status, which is then applied to optimize curriculum objectives, content, and implementation processes, thereby forming a "design-implementation-evaluation-optimization " closed loop.

5.2 The Curriculum Construction Model of AI and PBL Integration

Based on the integration of AI and PBL, a "four-dimensional integrated" curriculum construction model should be established, which is specifically divided into the following dimensions, as shown in Figure 1 below:

Goal Level: Focuses on cultivating core literacy and clarifies the integration direction through a four-dimensional synergy target system, consisting of a Knowledge Map, Competency Map, Literacy Map, and Thinking Map. Knowledge Goal: Master discipline-specific knowledge related to the project. Competency Goal: Enhance problem-solving, collaborative innovation, and digital application abilities. Literacy Goal: Foster a rigorous scientific attitude and team cooperation spirit. Thinking Goal: Based on disciplinary characteristics, cultivate new talents with a sense of national identity, professional ethics, and social responsibility.

Content Level: Integrates AI technology and project tasks to reconstruct curriculum content. First, select project themes based on real enterprises, clarifying tasks, timelines, and outcome requirements for each theme. Then, provide foundational empowerment through well-designed curriculum modules and deepen practical application. In the practical phase, students are required to embed AI technology, using AI tools appropriate for their academic level to solve problems encountered during project implementation. Evaluation iteration via AI technology feeds results back into project-based learning, creating a closed loop that sustains the project-based curriculum.

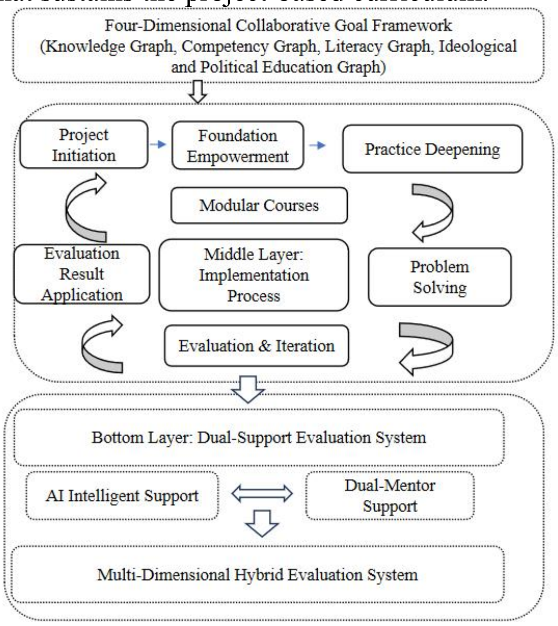

Figure 1. Curriculum Construction Model Based on the Integration of AI and Project-Based Learning

Implementation Level: Takes AI technology and project tasks as carriers, supported by integrated AI tools and project mentors. In the project initiation phase, the AI platform pushes case background materials, videos, etc., for students to conduct personalized preview. In the project implementation phase, the AI platform monitors students' learning status and project progress through learning data. In the project collaboration phase, the AI platform supports real-time group communication, problem diagnosis, and intelligent guidance, with AI agents providing targeted tutoring. In the project presentation phase, the AI platform showcases students' project outcomes to facilitate evaluation. Evaluation Level: Involves enterprise mentors providing practical guidance, with AI technology and dual mentors supporting the evaluation system.

AI-assisted multi-dimensional comprehensive evaluation: On one hand, the AI intelligent platform automatically collects data such as preview completion, project progress, and collaborative contribution to generate process evaluation reports. On the other hand, university and enterprise mentors conduct subjective evaluations of project innovation, collaboration, and team spirit based on AI's objective assessment. Meanwhile, the AI platform's data records are used to assess students' abilities in communication, innovative thinking, etc., forming multi-dimensional evaluation results.

6. Conclusion

By sorting out domestic and international research progress, analyzing theoretical foundations and practical pain points, this paper constructs a "goal-content-implementation-evaluation" four-dimensional integrated curriculum construction model, providing a systematic solution for the in-depth integration of AI and Project-Based Learning (PBL) under the background of smart education. This model integrates teaching content into curriculum modules based on AI technology and PBL, optimizes the implementation process through the integration of AI and PBL teaching methods to improve teaching effectiveness, and enhances education quality with a more comprehensive evaluation approach. However, the current research still has limitations: it fails to fully consider the characteristics of different academic stages and lacks in-depth exploration of the ethical risks associated with AI technology application. In the future, further research can be conducted by combining the teaching characteristics of different academic stages and the ethical norms of AI technology application, thereby promoting the continuous development of the integration model of AI technology and PBL.

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