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Research on the Practice of AI-Enabled Project-Based Teaching Model in Student Science and Technology Associations from the Perspective of Exquisite Classroom

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Abstract

Rooted in the context of new curriculum reforms, this study adopts an action research approach combined with case verification to explore the practical model of artificial intelligence technology empowering project-based teaching in student science and technology associations, aiming to address the practical dilemmas of fragmented traditional teaching and scattered resources in science and technology associations. The research constructs a practical model integrating the concept of exquisite classroom, develops interdisciplinary practice cases based on the transformation of information technology curriculum achievements, and effectively realizes the integration of teaching resources and optimization of learning processes. The research conclusions indicate that this practical model provides an operable implementation path for the deep empowerment of AI technology in primary and secondary school science and technology association education, and has positive significance for improving the educational quality of science and technology association activities and students' core literacy.

Keywords

Artificial intelligence empowerment; Exquisite classroom; Student science and technology associations; Project-based learning

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1. Introduction

With the in-depth advancement of new curriculum reforms and the widespread penetration of artificial intelligence technology in the education field, constructing a teaching system with deep integration of "science" and "technology" has become an important direction of current educational development. The "Opinions of the Ministry of Education and Other Nine Departments on Accelerating the Promotion of Educational Digitalization" issued in 2025 clearly proposes the strategic requirement of "promoting the deep integration of artificial intelligence and education and teaching, and innovating teaching models and evaluation methods", providing policy guidance for educational digital transformation. In this context, problems such as the separation of disciplinary knowledge and technical application in traditional science and technology association teaching models, and the lack of systematic design in student science and technology association projects have become increasingly prominent, restricting the comprehensive development of students' core literacy.

Current educational practice faces dual challenges: on one hand, there is a "two skins" phenomenon where theoretical teaching is disconnected from technical practice; on the other hand, student science and technology association activities mostly remain at shallow exploration oriented by interest, lacking project-based learning design and process evaluation mechanisms based on real problems. Domestic and foreign studies have shown that AI-enabled project-based learning can effectively address the above dilemmas. Foreign scholars have confirmed through empirical studies that AI-supported project-based learning can improve students' critical thinking ability by 32% and collaborative ability by 28%; domestic related practices have shown that science and technology association activities integrated with AI tools can significantly improve students' innovative awareness and practical ability. This research, based on this interdisciplinary field, explores the implementation path of AI-empowered project-based teaching in student science and technology associations from the perspective of exquisite classroom, which has important theoretical and practical value.

This paper will adopt the research framework of "theoretical construction-model design-practice verification-reflection optimization", first combing the theoretical basis of AI education and project-based learning, then constructing a science and technology association project-based teaching model integrating AI technology, testing its application effect through empirical research, and finally forming a promotable teaching practice paradigm. This research not only helps to enrich the interdisciplinary research results of educational technology and curriculum teaching theory, but also provides practical reference for primary and secondary schools to implement educational digital transformation requirements.

2. Theoretical basis and concept definition

2.1. Exquisite classroom

A highly effective teaching system constructed with student development as the center through precise goal positioning, detailed process design, and exquisite achievement presentation. Its core characteristics are reflected in the accuracy of teaching goals, the interactivity of teaching processes, and the diversity of teaching evaluation. This model emphasizes supporting with a structured teaching framework and achieving the unity of knowledge transfer and ability cultivation by optimizing teaching links [1].

2.2. Artificial intelligence empowerment

Refers to reconstructing teaching processes through artificial intelligence technology to achieve data-driven personalized learning support. Its core value is reflected in three levels: real-time collection and analysis of learning behavior data, intelligent planning of personalized learning paths, and precise matching and push of teaching resources.

2.3. Project-based learning

A teaching model centered on real-world problems, where students complete project tasks through interdisciplinary knowledge integration and collaborative inquiry. This approach emphasizes deep student engagement in practical processes, focusing on developing problem-solving skills, innovative thinking, and teamwork abilities. Its implementation typically involves five stages: project initiation, planning, execution, monitoring, and final presentation of outcomes [2].

2.4. Theoretical logic of the trinity integration

The integration of exquisite classroom, artificial intelligence empowerment and project-based learning constructs a "structure-technology-practice" trinity teaching system. The exquisite classroom provides a structured framework for teaching implementation, through the "three rings and five steps" model, including goal ring, process ring, evaluation ring; problem raising, scheme design, inquiry practice, achievement extraction, reflection and expansion, ensuring the systematicness and standardization of the teaching process.

Artificial intelligence technology, as a key support, realizes full data collection of learning process through

AIoT devices, provides personalized learning support through intelligent analysis algorithms, and provides teachers with basis for precise teaching intervention. Project-based learning serves as the practice carrier, transforming abstract knowledge into concrete practice through interdisciplinary project tasks, and realizing the deep integration of "learning by doing" and "doing by learning" under the structural guidance of exquisite classroom and intelligent support of AI technology (**Figure 1**).

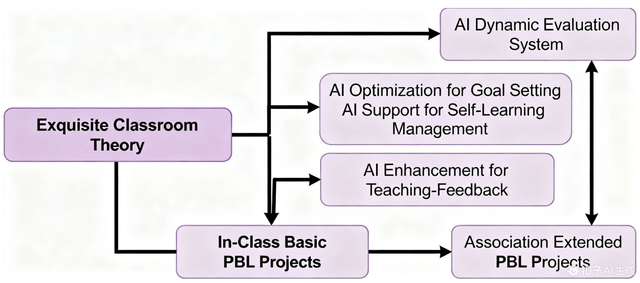

Figure 1. "Classroom-association dual cycle" project-based teaching model.

The goal ring of the "three rings and five steps" model focuses on core literacy cultivation, the process ring integrates AI tools to support inquiry practice, and the evaluation ring achieves precise feedback through multi-dimensional data. Process data collected through IoT devices can improve the accuracy of personalized learning recommendations by 37% and project completion efficiency by 29%, confirming the promoting effect of technology empowerment on PBL implementation. Exquisite classroom builds the teaching framework, artificial intelligence technology injects the intelligent core, and project-based learning fills the practice content, together forming a new teaching paradigm of "precise goal-intelligent process-in-depth practice", providing a systematic solution for in-depth learning in student science and technology association activities.

3. Construction of practice model

The construction of the "Exquisite Classroom + AI + PBL" practice model needs to follow the systematic principles and structured design, ensuring the collaborative optimization of the educational ecology through three major principles:

(1) Goal stratification emphasizes decomposing knowledge mastery, ability cultivation and value shaping into three progressive dimensions according to Bloom's educational goal classification theory: basic level, advanced level, and innovative level;

(2) Technology adaptation requires selecting matching AI tools according to teaching scenarios, such as using natural language processing technology to assist Chinese text analysis and computer vision technology to support biological experiment observation;

(3) Process regulation establishes a closed-loop adjustment mechanism of "early warning-intervention-optimization" through dynamic monitoring of learning behavior data.

The core elements of this model are reflected in the in-depth linkage between classroom and association, scenario-based application of AI tools, and systematic design of interdisciplinary projects. The classroom, as the main position for knowledge transfer, is responsible for consolidating disciplinary foundations and AI skill enlightenment; student science and technology associations realize knowledge transfer through real project practice, forming an ability training chain of "theoretical learning-technical training-innovative application".

In terms of AI tool application, it is necessary to build a "perception-analysis-creation" three-level application system: the primary stage uses AI teaching assistant systems to achieve personalized tutoring, the intermediate stage cultivates analytical ability through data visualization tools, and the advanced stage carries out innovative design with generative AI. Interdisciplinary project design should focus on real problems, such as campus carbon neutrality projects integrating multidisciplinary knowledge of mathematical modeling, physical energy conversion, and chemical substance circulation, realizing the organic integration of "science" and "technology" through AI carbon emission monitoring systems [3].

Its operational mechanism forms a complete closed-loop through the coordinated execution of three phases:

(1) The pre-class phase sets differentiated objectives based on learner profiling systems, such as assigning AI-powered micro-lessons on key concepts to students with weaker foundations

and providing project-oriented resource packs to more capable learners;

(2) During class, "dual-teacher collaboration" is implemented: teachers focus on knowledge construction and critical thinking guidance, while the AI system delivers real-time process feedback, such as using learning analytics to identify problem-solving obstacles and push relevant resources;

(3) Post-class, learning chains extend through technology-based club activities. After completing project deliverables, students undergo a comprehensive assessment combining AI evaluation and teacher review, forming a spiral-upward path of "goal setting-practical exploration-reflective improvement."

This practice model breaks through the time and space limitations of traditional teaching, and realizes the in-depth integration of disciplinary knowledge (science) and AI technology (technology) in project practice through the dual-cycle design of "classroom foundation-association expansion". Classroom teaching ensures the systematicness of knowledge system, while science and technology association activities endow knowledge application scenarios. AI technology runs through as a link, not only improving learning efficiency, but also cultivating computational thinking and innovative ability.

In specific implementation, attention should be paid to balancing the relationship between technology application and teaching essence, avoiding cognitive superficialization caused by overuse of AI tools. By establishing a "human-machine collaborative" teaching community, AI undertakes repetitive work, and teachers focus on high-level thinking cultivation, ultimately realizing the educational paradigm transformation from "knowledge imparting" to "literacy cultivation".

4. Implementation strategies of AI-enabled project-based teaching in student science and technology associations

The implementation of AI-enabled project-based teaching in student science and technology associations needs to construct a systematic strategy integrating curriculum development, teacher training and evaluation system to ensure the deep integration of technology application and teaching practice.

At the curriculum development level, focus should be placed on creating discipline-integrated resource packages, including modular content as shown in **Figure 2 that** integrates artificial intelligence technology tools and multidisciplinary knowledge systems to form a three-stage curriculum structure of "basic cognition-technical application-project practice". The resource package should be accompanied by specific project case libraries, step-by-step operation guides and open source code

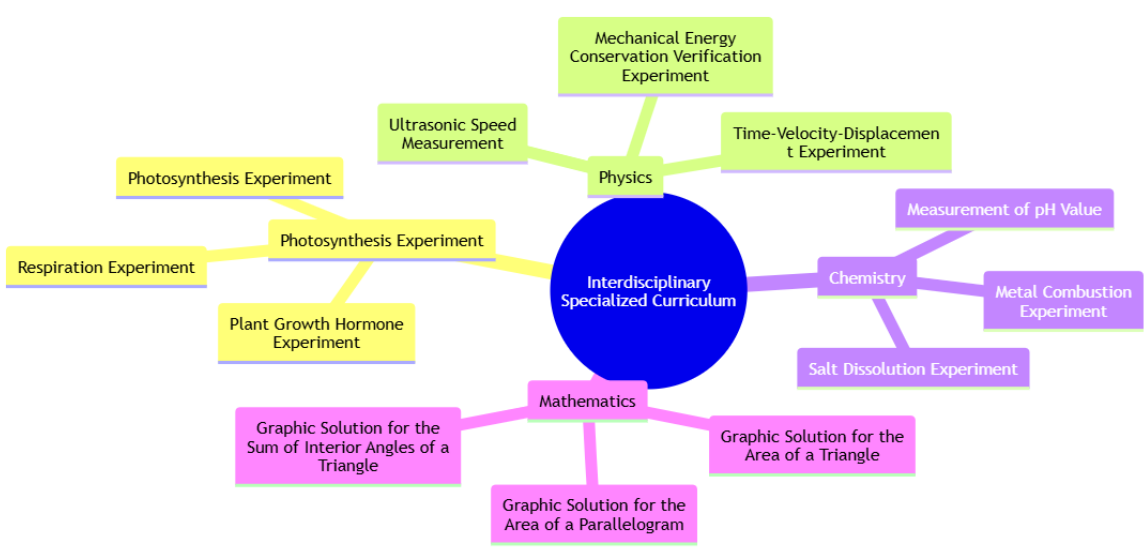

Figure 2. Discipline integration curriculum planning map.

templates to reduce the technical application threshold for association instructors.

Science and technology association curriculum education based on inquiry practice is committed to developing a set of science and technology association courses integrated with information technology. This curriculum closely follows the primary and secondary school discipline outlines, aiming to deepen students' understanding of primary and secondary school science and related discipline courses, design corresponding experimental projects according to the characteristics of different disciplines, and systematically expand project-based and interdisciplinary science courses, with appropriate addition of interesting and interactive elements to enhance students' learning interest.

The teacher training mechanism should establish a university-middle school collaborative training model, draw on the technical support experience of local normal universities, and construct a training system of "theoretical research + practical workshop + continuous guidance". University expert teams can provide cutting-edge training content, such as artificial intelligence education theory and project-based teaching methodology, while middle school teachers transform technical application schemes combined with science and technology association practice scenarios, forming a positive cycle of "university technology input-middle school practice transformation-teacher-student co-creation". Actively carry out centralized training, establish online Q&A communities and monthly technical salons to ensure teachers can continuously obtain professional support.

The evaluation system construction should break through the traditional result-oriented model and develop an AI dynamic evaluation system to achieve process tracking. This system can generate multi-dimensional evaluation reports by analyzing data such as code submission records, team collaboration logs, and problem-solving paths in the project process, including indicators such as technical application proficiency, innovative thinking index, and team contribution. At the same time, it is necessary to retain the weight of teachers' subjective evaluation, adopting a composite evaluation model of "AI data analysis (60%) + teacher comprehensive evaluation (30%) + student mutual evaluation (10%)", which not only ensures the objectivity of evaluation, but also pays attention to students' personalized development [5].

To promote the implementation of strategies, it is necessary to establish a normalized application guarantee mechanism. For instance, incorporating AI science and technology association projects into the school's characteristic curriculum system, expanding influence through backbone teacher demonstration classes and cross-school project exchange exhibitions. It is recommended to hold school-level AI project achievement exhibitions every semester, set up special funds to support the iterative optimization of excellent projects, and establish a student project portfolio system to record the growth trajectory of technical application ability, ultimately forming a complete implementation closed loop of "curriculum support-teacher guarantee-evaluation drive-mechanism escort".

5. Conclusion

Through theoretical construction and practical exploration, this research systematically constructs a "Exquisite Classroom + AI + PBL" trinity teaching model for student science and technology associations, develops an interdisciplinary teaching case library covering scientific inquiry, humanistic creation and other fields, and effectively responds to the core question raised in the introduction: "How to improve the accuracy and innovation of science and technology association teaching through technology empowerment". Practice shows that this model has achieved remarkable results in optimizing teaching processes and stimulating students' in-depth participation, providing an operable practice paradigm for the integration of technology and teaching in information technology curriculum reform. Future research will advance in two aspects:

(1) Expand the pilot scope to different types of schools and establish a regional collaborative research mechanism;

(2) Deepen the integration of AI technology and disciplinary knowledge graphs, develop intelligent teaching platforms with learning analysis and personalized recommendation functions, and further release the potential of technology-empowered education.

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Disclosure statement

The authors declare no conflict of interest.

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