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Exploration of AI-Empowered Interdisciplinary Integrated Project-Based Learning in Primary and Secondary Schools

Mingxia Zhang*, Decheng Zhang, Jinxin Chen

Yancheng Teachers University, China

***Corresponding author:** Mingxia Zhang, zmxjiaoxue@163.com

Abstract: In today's rapidly evolving technological landscape, AI is profoundly influencing and reshaping the educational ecosystem. Leveraging artificial intelligence to empower interdisciplinary project-based learning in primary and secondary schools has become a key theoretical and practical focus. Constructivist learning theory emphasizes context, collaboration, discourse, and meaning construction. This theory strongly supports interdisciplinary learning, while current applications of AI technology in creating contexts, facilitating efficient student collaboration and discourse, and enabling active meaning construction also represent a significant advancement in promoting constructivist learning theory. In practice, whether utilizing AI for resource organization and analysis, questionnaire design, learning design, or evaluation, it is essential to define clear roles, refine tasks, and provide specific requirements. AI tools are no longer mere question-and-answer thought partners; intelligent agents with robust reasoning and proactive tool utilization capabilities have become powerful assistants in implementing and evaluating project-based learning. The exploration of AI-enabled interdisciplinary project-based learning in primary and secondary schools demonstrates that technological advancements have driven rapid transformation in education. This will also hold profound contemporary significance for promoting educational equity, enhancing teacher and student capabilities, and ultimately achieving the goal of "delivering education that satisfies the people."

Keywords: Artificial intelligence; Project-based learning; Interdisciplinary integration; Human-AI collaboration

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1. Introduction

The rapid development of artificial intelligence technology has brought unprecedented transformation to primary and secondary school teaching. A combination of AI tools with diverse functions and abundant digital resources aids teachers in lesson preparation, implementation, and evaluation, while also fostering students' problem-solving abilities, innovative thinking, and collaborative spirit.

Interdisciplinary project-based learning emphasizes the integration of knowledge from different disciplines and promotes learning through solving real-world problems, facilitating meaningful construction. This process requires students to collaborate in problem-solving contexts, continuously practice and explore, and emphasizes "learning by doing" [1].

The development of secondary school education must align with the needs of the times. Hui Jinpeng stated: "We will dedicate efforts to cultivating a large number of teachers with digital literacy, strengthening the construction of our teaching workforce, and integrating artificial intelligence technology into the entire process and every aspect of education, teaching, and management. We will study its effectiveness and adaptability to enable the younger generation to learn more proactively and allow teachers to teach more creatively."

2. Theoretical support and practical significance

The concept of project-based learning particularly emphasizes a student-centered approach, real-world problem-driven learning, and "learning by doing." The integration of artificial intelligence provides intelligent support for project-based teaching, while also opening new perspectives for addressing various practical challenges in education, such as targeted personalized tutoring, teaching resource allocation, experimental safety precautions, equipment utilization, and process-oriented evaluation data support.

2.1. Theoretical support

Artificial intelligence empowers interdisciplinary project-based learning in primary and secondary schools by leveraging AI technology to cultivate students' comprehensive competencies. It creates contextual scenarios, enhances collaboration and dialogue, and promotes active meaning construction among students. This further exemplifies the application of constructivist learning theory supported by current technological advancements [2].

2.2. Practical significance

The important practical significance of empowering interdisciplinary integrated project-based learning in primary and secondary schools with artificial intelligence lies in the development of teachers' digital literacy abilities, promoting the transformation of interdisciplinary learning in primary and secondary schools from "experience-driven" to "data-driven", and better enhancing students' problem-solving abilities and comprehensive literacy. All of these meet the requirements of educational innovation under the current trend of technological development.

2.2.1. Promoting teacher professional development and innovative teaching models

AI is not only an application tool but also a "thinking partner" for teachers and more likely an "expert-level colleague" around them. It has become a key force driving teaching change. The effective implementation of interdisciplinary integrated project-based learning empowered by artificial intelligence in primary and secondary schools requires teachers to fully master the modern educational technology of artificial skills: creating scenarios, paying attention to students' personalized development, and achieving one of the goals of educational value. This puts forward new requirements for teachers' digital literacy: how to use artificial intelligence to hand over basic tedious and repetitive work (such as data collection, organization, and analysis) to technology processing, so as to focus more on core educational work such as guiding students' higher-order thinking and personalized guidance.

Building a new teaching relationship of human-machine collaboration: The human-machine collaborative education model complements human intelligence and machine intelligence through interaction, empowering interdisciplinary integrated project-based learning in primary and secondary schools with artificial intelligence, achieving resource preparation assistance, personalized guidance, intelligent tracking and evaluation, etc. These processes are dominated and dominated by humans, with human-machine complementarity. Of course, technology is no longer just a tool but a collaborative relationship of "student-teacher-machine" [3].

2.2.2. Promote the development of students' comprehensive literacy and ability to solve complex problems

Empowering interdisciplinary integrated project-based learning in primary and secondary schools with artificial intelligence is an important path to promote the development of students' comprehensive literacy and ability to solve complex problems. Its main advantage lies in using real problems as the basis for creating scenarios, empowered by artificial intelligence, and promoting students' thinking training and ability development.

This process, even with the powerful assistance of artificial intelligence, still requires students to take the lead in problem expression, critically face the output of AI, and avoid only becoming problem proposers. Therefore, in the process of project-based learning, it is necessary to further enhance students' systematic thinking, collaboration ability, and digital literacy. Students are not only proficient in using AI tools but also able to master AI, solve complex problems in interdisciplinary learning, and adhere to human subjectivity and value judgments.

3. Overview of AI empowering interdisciplinary integration project-based teaching implementation in primary and secondary schools

3.1. Utilize artificial intelligence to grasp every effective resource

Utilize artificial intelligence to parse, transform, and store resources, as shown in **Figure 1**.

Figure 1. Screenshot of Tencent ima's AI assisted video resource analysis. Source: https://www.iqiyi.com/v_b19drulirg.html

As shown in **Figure 1**, use the "Recording Minutes" in "Tencent ima" to organize the text. Copy the organized text information to DeepSeek with requirements such as: "What inspirations does this have for interdisciplinary project-based learning in primary and secondary schools?"

When the task is assigned to DeepSeek, there is a presentation of the "thinking" process, which can be carefully reviewed as it reflects a logical thinking process that is crucial for interdisciplinary understanding in education. There are many parts of the thinking process that are worth learning from.

Afterwards, DeepSeek provided a very vivid example and direct inspiration for interdisciplinary project-based learning (PBL) in primary and secondary schools, as well as related insights.

Of course, further questions can be asked in the current conversation, such as: What are the related disciplines? DeepSeek provides recommendations for core disciplines, expanded disciplines, interdisciplinary topic classification, and key discipline combinations recommended by academic stage.

Note: Tencent ima, test version number: 2.5.1 (4262); DeepSeek is used for official website login.

Utilize artificial intelligence technology to organize and store a knowledge base.

3.2. Utilizing artificial intelligence for data collection

The project-based learning process requires attention to students' learning interests and existing foundations, as well as teachers' understanding of the integrated courses in project-based learning. Before conducting project-based learning, a questionnaire can be set up to collect relevant information.

For project-based learning needs, such as before the interdisciplinary project "Exploring Technology-Empowered IoT", for students and subject teachers to design questionnaires, DeepSeek can be used to design the questionnaire and export it in txt format. At this point, it should be "New Dialogue Mode." Afterwards, on "Questionnaire Star" (https://www.wjx.cn/app/themehtml/wjxai.aspx), utilize AI to generate questionnaires, provide files to the platform, reorganize, check, and publish them. After collecting data, detailed analysis can be downloaded online to provide a basis for project-based learning.

3.3. Utilizing artificial intelligence to design and plan project-based learning

Using artificial intelligence tools such as DeepSeek to create course design drafts, during the "thinking" process of DeepSeek, the study will pay attention to how AI analyzes problems from multiple perspectives, provides suggestions for expanding thinking, and comprehensively searches for resources to produce course design drafts.

For content that requires graphical or tabular representation, graphs or tables should be created and further developed based on them. If some projects may involve instruments or drugs, is it necessary to purchase them, and is there a possibility of virtual experiments.

With the theme of "The Cell Structure of Onion" and the help of AI from text-to-image, such as Jimeng (https://jimeng.jianying.com/ai-tool/generate?workspace=13190760540684), select the role of a current student and obtain the image results shown in **Figure 2**. Even based on the generated images, videos can be generated for multi-angle observation.

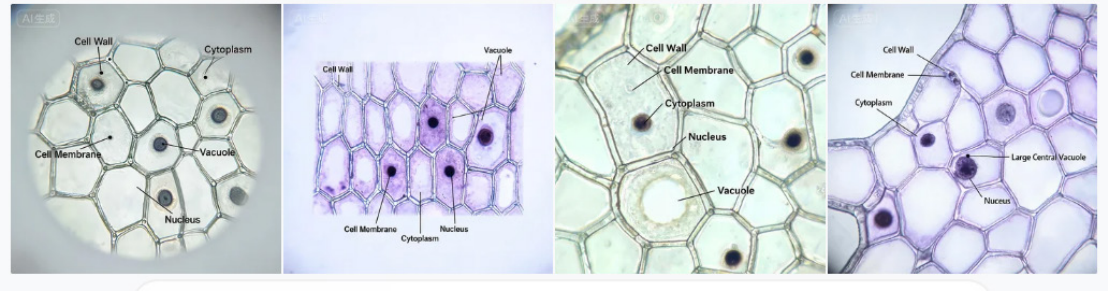

Figure 2. AI-generated onion cell structure image (student perspective)

3.4. Utilizing artificial intelligence to implement and evaluate project-based learning

In the implementation process of project-based learning, on the one hand, the advantages of learning technology should be fully utilized, such as virtual simulation experiments, project data collection and analysis tools, interactive courseware, micro courses, etc., applied to project-based learning to effectively enhance students' scientific exploration ability.

On the one hand, AI agents can utilize the reasoning ability of large models to achieve task planning, decomposition, and integration, and can directly use tools such as manipulating computers, browsers, and calling plugin tools.

With the development of technology, it has become possible for teachers to use platforms to develop intelligent agents. For example, by using AI agents to create personalized models, knowledge graph technology can track students' understanding of concepts, while pushing suitable learning tasks and exploration projects for students, customizing personalized learning paths for each student, and cultivating students' core chemistry literacy. At the same time, evaluations for interdisciplinary project-based learning can be integrated to provide personalized feedback and improvement suggestions for students. As on the platform (http://chatai.dljyxxzx.cn/?hometype=chat), when setting model requirements and inputting student data for evaluation, provide evaluation suggestions.

From the above process, it can be seen that AI is no longer just a tool application, but a more suitable role is "thinking assistant" or "thinking partner." The authors have gone through the process from issuing instructions to negotiating adjustments. It can be seen that AI has strong capabilities, but lacks clear background knowledge, goals, requirements, and even details of the information. So, providing background, context, goals, etc., to AI can effectively help solve related problems.

AI is not meant to replace teachers, but to liberate them from complex tasks and enable them to engage in more warm and creative education [4].

4. Conclusion

Sam Altman, co-founder of OpenAI, an artificial intelligence laboratory, has repeatedly predicted that AI will have "doctoral-level" capabilities and has also mentioned that in the future, human work will rely on AI collaboration rather than being completely replaced. Faced with numerous artificial intelligence tools, one should choose according to their needs and use them wisely. Artificial intelligence empowers interdisciplinary integrated project-based learning in primary and secondary schools, based on the design of challenging interdisciplinary integrated project practices, promoting the improvement of teachers' digital literacy while also assisting students' comprehensive development of innovation and cooperation abilities and actively engaging in knowledge construction. At the same time, it helps to promote educational equity and assist in "providing satisfactory education for the people."

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