Journal of Science Education

ISSN 0124-5481

Breaking Disciplinary Boundaries in Teacher Development: A Case Study on Cultivating Interdisciplinary Project Design and Implementation Competence among Teachers at Bayi School

Yujuan Ma[a], Huabei Wang[a], Xi Chen[a*]

[a] *Beijing Bayi School, Beijing 100080, China*

[*]*Corresponding Author*

ARTICLEINFO

Keywords:
STEM
Teacher Development
Interdisciplinary Teaching

ABSTRACT

In the context of educational digital transformation and competency-based education, Beijing Bayi School explores a new path for teacher development by leveraging STEM-driven interdisciplinary teaching. Through authentic projects and the dual support of intelligent technologies and ecological restructuring, teachers transition from single-subject thinking to interdisciplinary competence. This article highlights how interdisciplinary project-based learning across school levels fosters teachers' growth from adopters to innovators. The school's integrated system—including the "Third Space" and "123N" training model — provides sustained support for personalized, collaborative professional development. The practice demonstrates that breaking disciplinary boundaries is both a reform imperative and a catalyst for teacher growth.

1. Introduction

In the new era driven by educational digital transformation and the cultivation of core competencies, the role of teachers is undergoing fundamental changes — from "instructional executors" to "guides of values," from "single-subject instructors" to "interdisciplinary collaborators," and from "knowledge transmitters" to "designers of intelligent and digital learning." Beijing Bayi School has taken STEM-enabled interdisciplinary teaching as a breakthrough point, focusing on cultivating teachers' capabilities in interdisciplinary project development. Through the dual driving forces of "intelligent empowerment + ecological restructuring," the school has explored a new path for teacher development that breaks down disciplinary silos. Today, from the three dimensions of authentic case practices, developmental systems, and competency training models, I will share how our school uses interdisciplinary projects as a linking thread to promote the transformation of teachers from "single-subject thinking" to "multi-dimensional integration competence," ultimately achieving mutual empowerment in cultivating innovative talents and enhancing teacher professionalism.

2. Empowering and Enhancing Interdisciplinary Teaching Practices through STEM Education

The STEM Education 2035 Action Plan explicitly calls for the development of high-quality STEM curricula and project systems aimed at cultivating students' critical thinking, problem-solving abilities, and innovative practical skills, thereby advancing scientific higher-order thinking. STEM courses rooted in authentic engineering contexts serve as a key vehicle for achieving this goal. By deeply integrating science, technology, engineering, and mathematics into real-world engineering problems, and adopting a project-based learning path of "problem-driven – interdisciplinary integration – practical inquiry," these courses guide students to achieve knowledge integration, cognitive advancement, and competency development while solving complex engineering challenges — laying a solid foundation for training innovative talents capable of meeting future technological demands.

Over the years, Bayi School has emphasized the strategic importance of nurturing students with innovative thinking and engineering practice capabilities for national development. Leveraging its revolutionary legacy, the school has developed a STEM program with national defense and aerospace characteristics. Through platforms such as the Youth Aerospace Academy, students are guided to solve real-world problems. In the past five years alone, 1,700 students have won a total of 4,112 awards in science and technology competitions.

On March 25, 2025, our school hosted an interdisciplinary teaching seminar as part of the "Enhancing Science Education" pilot initiative. A total of seven research lessons were presented across elementary, middle, and high school levels, three of which were selected for lesson demonstrations at the "Enhancing Interdisciplinary Teaching through STEM" seminar hosted by Haidian District Institute of Teacher Training on March 27. This seminar centered on the theme "Empowering

Accepted February 2025, Available online 30 July 2025

Talent Cultivation through STEM," with the aim of deepening scientific education practices under the "Double Reduction" policy. The seven showcased lessons reflect the value of using STEM to design differentiated interdisciplinary teaching practices for different school levels. They also represent effective outcomes of our school's long-standing approach of integrating research and training, learning through doing, and innovating through inquiry, which provides a practical path for teachers to break disciplinary boundaries and pursue professional development.

At the elementary level, we fully consider students' cognitive development and focus on experiential learning of scientific inquiry through interdisciplinary projects, aiming to cultivate research awareness and a spirit of questioning. The project titled "South-to-North Water Diversion and the Siphon Engineering" was themed around "Exploring the Mysteries of Water Diversion Engineering." Leveraging the complexity and comprehensiveness of this major national project, students experienced a learning framework of "scientific inquiry – engineering design – system optimization." The project focused on core issues such as the siphon principle, route selection, and ecological protection. Through experimental investigation, sandbox simulation, and solution design, students engaged in interdisciplinary integration and real-world problem-solving, uncovering the scientific principles behind water diversion and developing systems thinking, innovative capability, and a sense of social responsibility.

At the middle school level, projects focused on stimulating scientific interest and reinforcing technological application. Students engaged in hands-on inquiry through active participation. For example, the math-integrated project "Kite Engineer – High-Altitude Photography System" was built around the core concept of problem-solving and rooted in authentic contexts. It established a closed loop of "sub-task entry – sub-problem exploration – learning outcome reflection." The driving question — designing a stable, camera-equipped kite—encouraged students to apply interdisciplinary knowledge, analyze and solve sub-problems at various stages, and complete iterative design and refinement, thereby enhancing their scientific literacy and collaboration skills.

At the high school level, the goal shifts from interest to committed engagement, emphasizing the establishment of a learning cycle of "scientific inquiry – engineering design – system optimization." It integrates multidisciplinary knowledge and cultivates students' higher-order thinking, interdisciplinary problem-solving skills, and social responsibility. The elective course "Mars Base Eco-Cabin" is a STEM course oriented toward scientific and engineering practice, targeting the development of higher-order thinking. By simulating the closed-loop resource requirements of a Mars base eco-cabin, students are guided to transfer knowledge from Earth's environmental issues to the engineering challenges of extreme space environments. This fosters the progressive development of higher-order scientific thinking, particularly in scientific reasoning, argumentation, and modeling. Deep learning is driven by task chains, such as tackling the complex issue of designing a thermal regulation module under Mars's low-gravity environment, which stimulates self-directed learning and inquiry. Through data sharing and collaborative testing between the science and engineering teams, students engage in group collaboration and iterative optimization. They continuously refine functional modules based on reflective analysis of anomalies, gradually constructing a comprehensive knowledge network.

These seven lessons underwent three rounds of iteration. From the perspective of teacher professional development, it is evident that teachers have progressed from conceptual adopters to reflective practitioners and are now striving to become leaders in curriculum innovation and generators of localized practice models.

3. Enhancing Teachers' Project Design and Implementation Competence through Interdisciplinary Practices Guided by Design Thinking

Bayi School provides ample space and opportunities for interdisciplinary exchange and learning among teachers. For example, the Rongzhen Research Institute in the secondary division and the Thinking Research Institute in the elementary division bring together many experienced teachers who, under the leadership of institute directors and with the support of expert teams, engage in immersive project-based learning experiences and cultivate their interdisciplinary project development competencies. These projects typically include: the creation of innovative learning environments; interdisciplinary project-based teaching grounded in design thinking; and the development of assessment systems aligned with new learning approaches and the cultivation of top-tier talent—including the fostering and evaluation of higher-order thinking, the transition from creative design to intelligent manufacturing, and the development of core competencies.

Take, for instance, the recent "Zero-Carbon Campus Curriculum Design" initiative led by the Thinking Research Institute.

The elementary school division has a campus farm of approximately 200 square meters, which previously lacked systematic resource utilization and quantification of its carbon footprint. Through initiatives such as farm planning, carbon measurement, and the cultivation of vegetables and flowers—supported by simple composting areas and rainwater collection systems — students are encouraged to participate in daily planting activities. These activities integrate resource utilization with carbon footprint analysis in a systematic way, helping students grasp basic carbon concepts, engage in carbon action, and develop scientific thinking.

To begin, teachers undergo expert-led thematic training on "PBL Curriculum Design for a Zero-Carbon Campus." Anchored in the core concept of the zero-carbon campus, the training includes experiential and hands-on courses that allow teachers to personally engage with and implement zero-carbon ideas. This enables them to shift from the perspective of "learner" to "curriculum designer," and ultimately develop interdisciplinary courses better suited to students' current learning and living contexts.

During project implementation, teachers use questioning techniques and instructional tools to help students connect invisible carbon emissions with real-life activities, thereby concretizing abstract concepts. Students are guided to ask questions—such as observing, identifying, and defining carbon-related concepts — and to explore issues related to carbon measurement, including definition, measurement techniques, and statistical analysis. This helps students build a mental model of carbon emissions that progresses from local phenomena to a holistic system. The project draws on knowledge from multiple subjects, including science, mathematics, and labor education, as well as various tools. Overall, it plays a significant role in fostering students' critical thinking and modeling abilities.

4. Fostering Teacher Growth through a Transdisciplinary Development System

Under the combined effects of the deepening "Double Reduction" policy and the ongoing digital transformation of education, the connotation and scope of what defines a "high-

Accepted February 2025, Available online 30 July 2025

quality teacher" are undergoing profound changes. Teachers are no longer merely transmitters of knowledge — they are also cultivators of students' core competencies, practitioners of educational innovation, and exemplars of lifelong learning. Teacher professional development is a nonlinear, multidimensional, and lifelong process, characterized by two key dynamics: phased progression and the synergy between internal and external factors.

Our school-based teacher training and development system is distinguished by the following features:

4.1. Integrative Innovation through Learning Communities and the Third Space

Learning Communities: From Isolated Development to Symbiotic Growth. The theory of learning communities emphasizes knowledge construction through collaboration and sharing. Centered around its Academic Committee, Bayi School Education Group has established various academic organizations to support this collaborative model.

The Third Space: A New Ecosystem for Blended Teacher Growth. Traditional teacher development has typically relied on the subject group (first space) and grade-level group (second space). In contrast, the third space transcends spatial and temporal constraints by integrating physical spaces such as the Teacher Innovation Center, Collaboration Center, Academic Institutes, and the Thinking Research Institute with digital platforms for academic inquiry and intelligent learning. This fusion achieves three key breakthroughs: ubiquitous access to resources, deepened interaction, and diversified evaluation mechanisms.

4.2. Refined Implementation of the "123N" School-Based Training Model

With the goal of providing personalized and precise support for teachers' professional development needs, we have established the "123N" training model.

1 Core Curriculum System:developed in alignment with the national 14th Five-Year Plan, the curriculum system is structured around a "four-dimensional, eight-pillar" framework to guide teacher development. 2 Types of Academic Organizations: comprising both subject-specific and interdisciplinary academic groups, these organizations are grounded in classroom teaching practices and focused on inquiry-based research driven by real educational challenges. 3 Major Development Programs: Qihang Program (Setting Sail): a mentorship initiative that pairs experienced and novice teachers. Through the "Smart Lesson Observation" system, classroom data is collected and analyzed using AI (e.g., frequency of questioning, student engagement ratio) to generate actionable improvement reports. Zhiyuan Program (Aiming Far): led by key teachers undertaking research projects. The school provides matched resources and platform-based support for the research process, data accumulation, and outcome dissemination. Bacui Program (Pursuing Excellence): expert teachers participate in curriculum development, distill research outcomes, and lead the translation of innovations into practice. N Self-Directed Research Topics or Projects: Teachers are free to select their research interests. The platform supports cross-school collaboration, fostering a full cycle of "research – practice – dissemination" .

5. Conclusion

Breaking down disciplinary boundaries is not only an inevitable trend in educational reform but also represents the "second curve" of teachers' professional growth. The practice at Bayi School demonstrates that only by using authentic projects as the crucible, intelligent platforms as the lever, and a culture of collaboration as the fertile soil, can we cultivate a new generation of teachers who possess both "disciplinary depth" and "interdisciplinary breadth".

Let us move forward together—enabling teachers to "cross boundaries" so that students may "create beyond". This is our response to the profound question posed by Qian Xuesen: how can we nurture top-tier innovative talents?

Acknowledgements

We would like to express our sincere gratitude to Director Chen Yongmei of the STEM Innovation Center at Haidian District Institute of Teacher Training for her long-standing support of teacher development.

Project Statement

This article is a phased achievement of the Beijing 14th Five-Year Education Science Planning Project titled: A School-Based Teacher Development System Empowered by Big Data Technologies for Novice Teachers (CBFB24105).

Accepted February 2025, Available online 30 July 2025