



# Construction of the NPBL Teaching Mode: Curriculum Restructuring of “Transportation Planning” for Cultivating Complex Systems Thinking

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**Abstract.** To address the limitations of traditional Problem-Based Learning (PBL) in accommodating the demands of complex engineering system courses and its inadequacy in fostering students’ complex systems thinking, this paper proposes a Nested Problem-Based Learning (NPBL) model. Following the definition of its conceptualization and structural framework, the NPBL model is systematically embedded into the entire curriculum restructuring process of the “Transportation Planning” course. The nested coupling relationships among NPBL projects, along with the implementation procedures and support mechanisms, are clearly articulated. Empirical research across two teaching cycles demonstrates that this model significantly enhances students’ complex systems thinking, engineering integration capabilities, and complex problem-solving skills. This study offers both theoretical and practical insights for pedagogical innovation in complex engineering courses within the context of Emerging Engineering Education.

**Keywords:** NPBL; Problem-Based Learning; Complex systems thinking; Transportation planning; Educational reform

## 1 Introduction

With the continuous advancement of Emerging Engineering Education and the full implementation of the “student-centered, outcome-oriented, and continuous improvement” philosophy in engineering education accreditation, the talent cultivation objectives for Transportation Engineering—a core discipline supporting the “Transportation Power” national strategy—are undergoing a profound transformation from knowledge transmission to competency development. Particular emphasis is placed on cultivating students’ abilities to solve complex engineering problems, engage in systems thinking, and integrate knowledge from multiple perspectives. As a core compulsory course in the Transportation Engineering program, “Transportation Planning” explicitly aims to equip students with the capacity to investigate and analyze urban transportation development patterns, apply scientific methods to forecast trans-

portation demand, formulate transportation plans, demonstrate innovative thinking, and solve complex problems. Furthermore, students are expected to develop the ability to conduct comprehensive evaluations of transportation plans from the perspective of sustainable urban development. These objectives are highly consistent with the core requirements of cultivating complex systems thinking.

## 2 Limitations of Traditional Teaching Approaches

In recent years, the rapid emergence and evolution of new technologies have led to a significant increase in applied, comprehensive, and practice-oriented courses within engineering curricula in higher education. Traditional teaching models have struggled to meet the complex demands of such courses. In response, universities have increasingly adopted Problem-Based Learning (PBL) [1], which replaces traditional lecture-based instruction with problem-driven inquiry and collaborative learning, thereby supporting the development of students' complex systems thinking. Numerous educators have conducted related empirical studies. In terms of pedagogical innovation and integration, Zhang et al. [2] combined the lecture-internalization phase of the Presentation-Assimilation-Discussion (PAD) model with the inquiry process of PBL, forming a closed loop of "lecture-internalization-inquiry" that addressed challenges related to students' weak foundational knowledge and lack of motivation. Zhao et al. [3] applied the BOPPPS model (Bridge-in, Objective, Pre-assessment, Participatory Learning, Post-assessment, Summary) to provide a structured framework for PBL, making the problem-oriented learning process more rigorous and controllable, thereby enhancing the achievement of instructional goals. Regarding the cultivation of practical skills and comprehensive competencies, Wang et al. [4] introduced real-world enterprise projects to construct a school-enterprise collaborative, project-driven teaching model, effectively fostering students' practical and innovative abilities. Sun et al. [5] integrated ideological and political elements into PBL problem design, enhancing students' research capabilities while strengthening their awareness of professional ethics and social responsibility. In the realm of technology-enabled learning and resource development, Chen et al. [6] utilized a SPOC platform to provide structured online resources that supported in-depth PBL inquiry in the classroom, achieving an organic integration of online and offline learning. Wang [7] systematically employed virtual reality, collaborative tools, and big data to create immersive problem scenarios, optimize collaborative workflows, and enable dynamic assessment of the learning process, thereby improving interactivity and personalization in teaching.

Overall, while PBL has demonstrated positive value in specialized course instruction, certain limitations persist. First, problem design is often fragmented and lacks systemic integration. Traditional PBL tends to decompose courses into discrete projects with weak linkages in terms of knowledge and data, making it difficult for students to establish connections between part and whole and to develop systemic understanding. Second, the absence of progressive mechanisms hinders cognitive development. Traditional PBL lacks a structured pathway from specialized inquiry to systemic integration; after completing individual projects, students struggle to transition from

linear to systems thinking. Third, weak coupling mechanisms undermine systemic cognition. The lack of coordinated drivers—including data integration, constraint alignment, and curriculum objective coherence—results in disconnected data across PBL projects and insufficient articulation of constraints, preventing students from analyzing the internal relationships within complex systems. Consequently, traditional PBL fails to provide students with a practical platform that enables a complete cognitive cycle of “system decomposition—localized deepening—systemic reconstruction.” As a result, it cannot accommodate the complex system characteristics of courses such as “Transportation Planning” [8] and falls short of meeting the requirements for cultivating students’ complex systems thinking.

### 3 Evolution from PBL to the NPBL Model

Problem-Based Learning (PBL) was first introduced by Howard S. Barrows [9], a professor of neurology, in medical education at McMaster University in Canada during the late 1960s. Its core principle is a teaching model driven by authentic problems, characterized by student-centered learning with instructors serving as facilitators, through which students acquire knowledge and enhance competencies via collaborative group work, independent inquiry, and interactive discussion. Since its inception, PBL has become a significant direction in global educational reform. Within engineering education, its applications have continuously evolved, primarily along three trajectories: First, deepening into Project-Based Learning (PjBL), which emphasizes the production of concrete solutions and involves longer duration and greater comprehensiveness. Second, evolving toward scaffolded or sequenced PBL, which designs a series of tasks with increasing difficulty or sequential dependencies to progressively develop student competencies. Third, expanding toward interdisciplinary course project clusters, attempting to transcend the limitations of individual courses by integrating multidisciplinary knowledge through large-scale comprehensive projects.

Despite these rich evolutionary developments and their demonstrated effectiveness, a critical issue remains overlooked. Specifically, within a single specialized course, there remains a lack of systematic model construction and empirical research on how to precisely simulate and cultivate systems thinking for solving complex engineering problems through hierarchically structured project groups characterized by rigorous internal logic and strong interactive coupling relationships. Existing research on “project sequences” and “project clusters” predominantly focuses on temporal order and skill scaffolding, emphasizing thematic relevance or interdisciplinary connections. However, it seldom examines, from a systems theory perspective, the construction of coupling relationships among sub-projects in terms of data, constraints, and objectives. Furthermore, it fails to explicitly incorporate the conflicts and coordination between sub-projects as pedagogical objectives for achieving the re-understanding and redesign of complex systems. Consequently, the absence of such nested structures and the imperative for outcome integration leaves students inadequately developed in systems thinking capabilities.

Within the spectrum of engineering pedagogies that emphasize comprehensiveness and holism, sequential PBL focuses on the progressive nature of tasks, interdisciplinary course project clusters emphasize thematic relevance or disciplinary intersection, and PjBL prioritizes the delivery of final products or design solutions. The distinctive value of the Nested Problem-Based Learning (NPBL) model proposed in this paper lies in its presupposed structural nesting and institutionally mandated integration. Through its nested macro-project and micro-project design, it establishes indivisible coupling relationships—in terms of data, constraints, and objectives—both among micro-projects and between micro-projects and the macro-project. By means of a “dual-cycle” process (where micro-project inquiry cycles are nested within the macro-project integration cycle), the cognitive process of “system decomposition—specialized deepening—systemic reconstruction” inherent in solving complex engineering problems is transformed from a tacit experience that may or may not occur and that depends on individual students’ cognitive abilities, into an explicit instructional process that is rendered inevitable through curriculum deconstruction and is both guidable and assessable. Therefore, NPBL is fundamentally distinct from sequential PBL, interdisciplinary course project clusters, and PjBL in its broader sense. This model addresses the challenge of cultivating students’ complex systems thinking within a single core specialized course through institutionalized design.

## **4 Construction of the NPBL Model: Definition, Framework, and Mechanisms**

### **4.1 Core Definition of NPBL**

NPBL, or Nested Problem-Based Learning, is a teaching model operationalized at the individual course level. Grounded in the Outcome-Based Education (OBE) philosophy and employing backward design, this model takes a comprehensive complex engineering problem (the macro-project) as its overarching objective. The macro-project is deconstructed into a series of progressively sequenced sub-problems (micro-projects) that are deeply coupled in terms of knowledge scope, foundational data, and phased objectives. Aimed at cultivating complex systems thinking, the model facilitates students’ capability transition from partial understanding to holistic mastery and from linear to systems thinking through a dual-cycle progressive process of “macro-project systemic integration and micro-project specialized inquiry.” This process is underpinned by a coupling-driven mechanism involving data flows, constraint flows, and objective flows, ultimately achieving the pedagogical goal of developing competencies for solving complex engineering problems.

### **4.2 Framework of the NPBL Model**

The NPBL teaching model constitutes a complete system encompassing core principles, implementation procedures, and support systems, with its framework illustrated in Fig. 1. It embodies two core characteristics. First, the nested structure of micro-

projects and macro-projects: All micro-projects are designed based on the decomposition of the macro-project objectives, and their outcomes must be inversely integrated into the macro-project solution. Second, the macro-micro dual-cycle progressive process: The “whole-part-whole” sequence constitutes a macro-level learning cycle. Within the “part” phase, each individual micro-project itself represents a micro-level cycle of “inquiry-practice-output.” This structure reflects the developmental patterns of cognition.

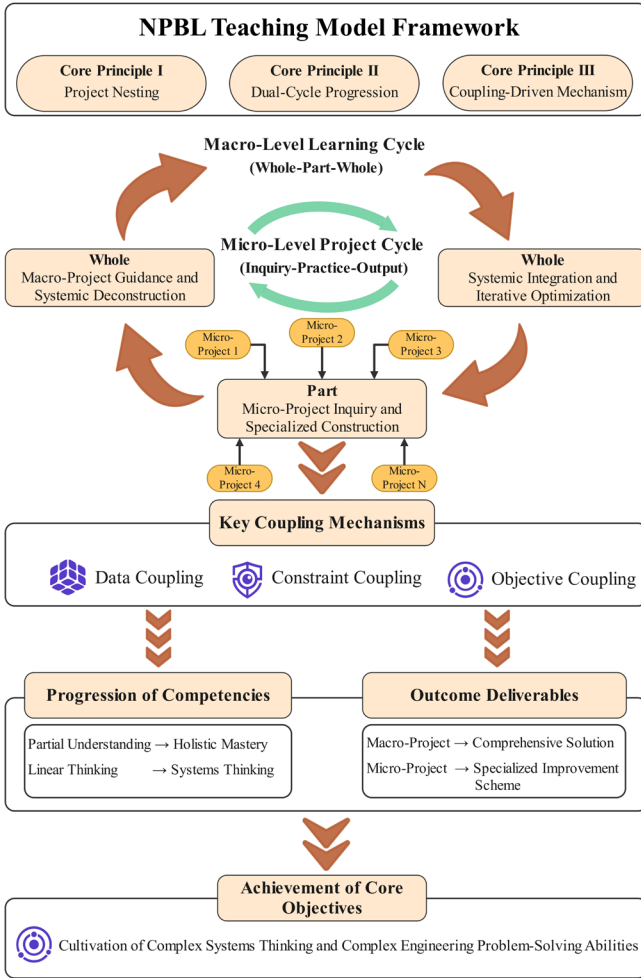


Fig. 1. Framework of the NPBL Teaching Model

### 4.3 Coupling-Driven Mechanism

The coupling-driven mechanism serves as the core guarantee for achieving systematicity in the NPBL teaching model, ensuring synergy between the macro-project and

micro-projects through deep coupling of objectives, data, and constraints. First, objective coupling constitutes the core of this mechanism. The inquiry objectives of each micro-project are deeply aligned with the overarching objective of the macro-project, establishing a “whole-part” hierarchy of objectives. Through objective coupling, all micro-project inquiries are ensured to revolve around and synergistically advance toward the macro-project’s overarching goal. Second, data coupling functions as the foundation of the coupling-driven mechanism. The data generated during the inquiry process of each micro-project are interconnected and mutually reinforcing, forming a coherent data chain across all projects. Third, constraint coupling serves as the safeguard of the coupling-driven mechanism. Each micro-project is governed by both common constraints and reciprocal constraints to ensure alignment with the overarching objective of the macro-project. Common constraints refer to the uniform conditions that all micro-projects must follow, while reciprocal constraints refer to the mutual restrictions and influences among micro-projects. Through constraint coupling, deviation from the overarching objective is prevented, ensuring that the outcomes of individual micro-projects are effectively integrated into the macro-project’s holistic solution. Taking the “Transportation Planning” course as an example, the specific coupling relationships are presented in Table 1.

**Table 1.** Coupling-Driven Mechanism of the "Transportation Planning" Course under the NPBL Model

Coupling Type	Objective Coupling (Core)	Data Coupling (Foundation)	Constraint Coupling (Safeguard)
<b>Macro-Project</b>	<p><b>Overarching Objective:</b> Cultivate students' complex systems thinking and ability to develop comprehensive transportation planning schemes</p>	<p>Aggregated data from all micro-projects support the formulation of comprehensive transportation planning schemes</p>	<p><b>Common Constraints:</b> Urban territorial space planning requirements, "Dual Carbon" goals, "Transportation Power" national strategy, relevant specifications and standards</p>
<b>Micro-Projects</b>	<p><b>Phased Objectives:</b></p> <ol style="list-style-type: none"> <li>1. Master investigation and analysis methods to provide data support for demand forecasting</li> <li>2. Conduct road network, public transit, and parking facility planning</li> <li>3. Master comprehensive evaluation methods for systematic assessment and optimization of planning schemes</li> </ol>	<p><b>Data transfer and linkage across stages:</b></p> <ol style="list-style-type: none"> <li>1. Traffic survey and data analysis yield traffic flow and travel characteristics data</li> <li>2. Input into forecasting models for transportation demand forecasting, yielding forecast results</li> <li>3. Based on forecast results, conduct road network, public transit, and parking facility planning scheme design</li> </ol>	<p><b>Reciprocal Constraints:</b> e.g., Road network layout constrains parking facility locations, while parking facility layout inversely constrains road network entrance/exit design</p>

**Table 2.** Instructional Units and Class Hour Design for the "Transportation Planning" Course

Instructional Unit	Instructional Content	Class Hours
Unit 1	Introduction to Transportation Planning	2
Unit 2	Traffic Survey and Data Analysis	6
Unit 3	Transportation Demand Forecasting	6
Unit 4	Transportation Network Analysis	2
Unit 5	Comprehensive Urban Transportation Planning	6
Unit 6	Urban Road Network Planning	6
Unit 7	Urban Public Transit Planning	6
Unit 8	Parking Facility Planning	6
Unit 9	Urban Transportation Management Planning	6
Unit 10	Comprehensive Evaluation Methods for Transportation Planning	2

## 5 Design and Implementation of the NPBL Model in the "Transportation Planning" Course

Based on the syllabus of the “Transportation Planning” course at Nanning University, this study takes “Comprehensive Transportation Planning for a New Urban District in 2035” as the macro-project that runs throughout the entire course, restructuring the original teaching content and procedures.

### 5.1 Nested Design of Macro-Project and Micro-Projects

The original syllabus consisted of 10 instructional units (as shown in Table 2). These were restructured into one macro-project and six core micro-projects, forming a tightly nested curriculum structure (as shown in Table 3).

### 5.2 Restructuring of the Teaching Process

The 48-credit-hour “Transportation Planning” course, delivered over 12 weeks, was restructured into three phases:

**Table 3.** NPBL-Based Restructuring Design Scheme for the "Transportation Planning" Course

Project Level	Project Name	Corresponding Syllabus Units	Core Driving Question	Deliverables	Coupling Relationships
Macro-Project	Comprehensive Transportation Planning for a New Urban District	All units	How to develop a comprehensive transportation system plan for the sustainable development of the new district?	Comprehensive transportation planning report, planning sketches	Overarching objective governs all micro-projects
Micro-Project	1 Current Situation Diagnosis and	Units 1, 2, 5	What are the current traffic characteristics and key	Current situation diagnosis report,	Provides planning objectives and constraints for all

	Development Strategy		problems in the new district? What transportation development strategy should be adopted?	transportation development strategy statement	subsequent micro-projects
2	Transportation Demand Forecasting Modeling	Units 3, 4	How will the population, employment, and transportation demand of the new district be distributed in 2035? Where will the main passenger and freight corridors be located?	2035 OD matrix, desire lines diagram of traffic zones	Provides core input data for Micro-Projects 3–5
3	Road Network System Planning	Units 5, 6	How to layout and design an urban road network that efficiently accommodates travel demand and supports urban spatial development?	Road network plan, road cross-section design	Inputs strategic objectives from Micro-Project 1 and data from Micro-Project 2; generates constraint conflicts with Micro-Projects 4 and 5 regarding space and resources
4	Public Transit System Planning	Units 5, 7	How to construct a competitive multi-level public transit service system coordinated with the urban road network?	Transit network plan, transit station layout sketch	Inputs strategic objectives from Micro-Project 1 and data from Micro-Project 2; deeply coupled with Micro-Project 3 (right-of-way allocation) and Micro-Project 6 (interchange connectivity)
5	Parking Facility System Planning	Units 5, 8	How to formulate parking supply, management, and layout strategies aligned with urban development and transportation strategies?	Parking zoning policies, public parking lot layout plan	Inputs strategic objectives from Micro-Project 1 and data from Micro-Project 2; objectives coupled with Micro-Project 3 (dynamic-static traffic coordination) and Micro-Project 1 (strategy)
6	Comprehensive Evaluation	Units 9, 10	How to integrate and optimize the subsystem plans? What are the comprehensive benefits and sustainability of the planning scheme?	Traffic organization and management plan, comprehensive evaluation report of planning scheme	Integrates and coordinates outputs from Micro-Projects 3–5; conducts multi-objective, multi-indicator evaluation; provides feedback for optimizing the macro-project scheme

Phase 1: Task Assignment and Deconstruction (Weeks 1–2): The macro-project task brief was released and student groups were formed. Instructors guided students in

conducting preliminary analyses of the complex planning problem for the new urban district, collaboratively deconstructing it into the aforementioned sequence of micro-projects and establishing a learning roadmap.

Phase 2: Specialized Inquiry and Iteration (Weeks 3–10): Micro-projects 1 through 6 were conducted sequentially. Within each micro-project cycle, theoretical instruction, case studies, and project work were integrated. At key milestones, “proposal review sessions” were held, during which instructors assumed the role of “planning experts” to challenge students’ proposals. Groups were required to use the outputs from each preceding micro-project as the design basis for the subsequent one.

Phase 3: Outcome Integration and Defense (Weeks 11–12): Each group synthesizes all outputs from the micro-projects, with particular attention to resolving systemic conflicts revealed during the integration process (e.g., contradictions between dedicated bus lanes and intersection channelization). Multiple scenario comparisons and optimizations are conducted to develop the final macro-project outcome, followed by report submission and an oral defense. This phase specifically features “integration and collaboration workshops,” where students are guided to employ systems thinking tools for decision-making.



a) Group discussion                      b) Micro-project review                      c) Macro-project defense

**Fig. 2.** On-site photographs of NPBL implementation

## 6 Teaching Implementation and Effectiveness Evaluation

### 6.1 Key Control Measures in the Implementation Process

To ensure the effective implementation of NPBL’s coupling mechanisms, an online collaboration platform was concurrently utilized to establish a dedicated project space for each group. Groups were required to upload the outcomes of each micro-project according to the data flow relationships, which served as inputs for subsequent micro-projects, thereby ensuring process traceability. (as shown in Fig. 2) During the review of each micro-project, role cards representing multiple perspectives—such as “government representatives,” “transit operators,” “citizen representatives,” and “review experts”—were introduced to guide students in examining the feasibility of their proposals from diverse stakeholder positions. Additionally, students were required to document their specific thought processes and decision-making justifications when receiving upstream data and coordinating solution conflicts. These documentations served as qualitative materials for assessing their systems thinking development.

Furthermore, compared to the traditional PBL model, students may experience initial discomfort and a heightened cognitive load during the early implementation stages of NPBL. To address this potential issue of cognitive overload, a multi-level support system should be implemented. First, during the project initiation phase, instructors and students collaboratively use visualization tools, such as mind maps, to diagram the project nesting and data coupling relationships, providing students with a holistic cognitive map of the course. Second, each micro-project strictly follows the BOPPPS micro-teaching cycle, in which the “pre-assessment” diagnoses prerequisite knowledge, while the “post-assessment” and “summary” provide immediate feedback, ensuring that the cognitive load at each step remains within a manageable range. Third, within group collaboration, team leaders assign clear roles based on members’ strengths, decomposing complex tasks effectively. Fourth, during the final system integration phase, multiple “conflict resolution workshops” are conducted to guide students in systematically identifying, analyzing, and weighing contradictions among micro-projects. Additionally, timely individualized guidance is arranged for groups encountering difficulties.

## 6.2 Effectiveness Evaluation and Analysis

### 6.2.1 Comparison of Academic Performance.

To validate the effectiveness of the proposed model, a comparative teaching experiment was conducted involving two classes across two complete instructional cycles in the Transportation Engineering program at Nanning University. Class 1 of Grade 2022 (43 students) from the first semester of the 2024–2025 academic year adopted a lecture-based approach supplemented by traditional PBL (control class). Class 1 of Grade 2023 (55 students) from the first semester of the 2025–2026 academic year implemented the NPBL teaching model proposed in this study (experimental class). Both classes were instructed by the same team of instructors, used the same core textbook content, and had identical total instructional hours.



**Fig. 3.** Schematic diagram of comparative analysis of academic performance between experimental and control classes

As shown in Fig. 3 and Table 4, the mean final course score of the experimental class (Grade 2023, Class 1) was 76.51, compared to 73.43 for the control class (Grade

2022, Class 1), representing an increase of 3.08 points. An independent samples t-test revealed a statistically significant difference between the two classes ( $t = -2.3326, p = 0.0218 < 0.05$ ), indicating that the examination performance in the “Transportation Planning” course differed significantly between the experimental and control classes. Regarding score distribution, the experimental class achieved an excellence rate (score  $\geq 80$ ) of 27.27%, substantially higher than the 20.93% observed in the control class. For the distinction rate (score  $\geq 90$ ), the experimental class achieved a breakthrough from zero compared to the control class. Additionally, the median score of the experimental class increased by 3.07 points relative to the control class. These comparative results across core indicators of academic performance demonstrate that the experimental class significantly outperformed the control class.

**Table 4.** Comparison of Core Academic Performance Indicators Between Experimental and Control Classes

Indicator	Control Class	Experimenta Class	Improvement
Mean Score	73.43	76.51	+3.08
Median Score	72.9	75.97	+3.07
Highest Score	88.55	93.98	+5.43
Lowest Score	61.4	62.74	+1.34
Excellence Rate ( $\geq 80$ )	20.93%	27.27%	+6.34%
Distinction Rate ( $\geq 90$ )	0.00%	3.64%	+3.64%

**6.2.2 Student Self-Assessment Questionnaire.**

Given the tacit nature and multidimensionality of complex systems thinking, direct standardized measurement poses significant challenges for exploratory investigations during the early stages of curriculum implementation. Accordingly, this study conducted a comprehensive analysis based on systematic questionnaire surveys examining students’ learning processes and outcomes. Upon completion of the course, a self-developed “Course Learning Experience and Self-Assessment Questionnaire” was distributed to students in the experimental class. The questionnaire design was informed by the core dimensions of complex systems thinking, encompassing four dimensions: systemic interconnectedness cognition, multi-objective trade-off decision-making, iterative and dynamic thinking, and knowledge integration and application. Each dimension comprised 3–5 questions aligned with course objectives and reflective of complex systems thinking capabilities, totaling 16 items, measured on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The questionnaire content was reviewed by three experts from both academic and professional backgrounds in the field of transportation planning.

As illustrated in the survey results (as shown in Fig. 4), the experimental class achieved mean scores ranging from 4.18 to 4.41 across the four dimensions of complex systems thinking, all falling within the high-score range and demonstrating strong overall performance. In contrast, the control class obtained mean scores ranging from 3.57 to 4.02 across all dimensions, placing them in the medium-score range

and exhibiting a marked disparity with the experimental class. Furthermore, over 80% of students in the experimental class acknowledged the course's effectiveness in cultivating their systematic analytical thinking regarding transportation problems. These findings substantiate that, compared to traditional teaching models, the NPBL model more effectively stimulates students' complex systems thinking and better aligns with the requirements of the "Transportation Planning" course for cultivating complex systems thinking capabilities in the engineering domain.

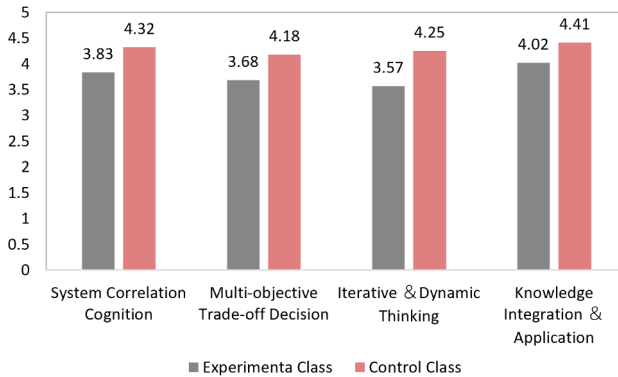


Fig. 4. Comparison of competency dimensions between experimental and control classes

## 7 Discussion and Conclusions

### 7.1 Theoretical Contributions and Practical Value of the NPBL Model

The theoretical contribution of the NPBL model lies in its proposition of a meso-level structured design theory for cultivating the higher-order competency of complex systems thinking. It effectively bridges the macro-level OBE educational philosophy with micro-level teaching activities, concretizing the abstract capability of solving complex engineering problems into an operable and replicable curriculum architecture comprising the "macro-project-micro-project" nested structure, dual-cycle teaching process, and coupling mechanisms. Compared to teaching methods, NPBL mandates through institutional design that students experience a complete systems thinking cycle, ensuring the attainability of competency development rather than relying on students' initiative. In practice, NPBL provides a comprehensive restructuring framework—from conceptualization to evaluation—for highly systematic engineering courses such as "Transportation Planning."

### 7.2 Implementation Challenges

The successful implementation of NPBL imposes higher demands on teaching teams, resource support, and institutional environments. The most critical challenge is the transformation of teachers' roles and competencies. Instructors must evolve from

lecturers to learning system designers and cognitive facilitators, requiring not only cutting-edge disciplinary knowledge but also systems engineering project experience and advanced pedagogical expertise. Second, the investment of time and effort is substantial. Initial course design—including macro-project scenarios, micro-project coupling, and assessment criteria—requires approximately two to three times the effort of traditional course preparation. During implementation, process guidance, micro-project reviews, and conflict resolution also demand considerable attention. Therefore, institutions must fully recognize this intensive course design effort in teaching workload allocation and performance evaluation. Additionally, comprehensive teaching resources should be provided, including: 1) interdisciplinary teaching teams to address multidimensional issues involving economics, environment, and society; 2) digital tools and platforms, such as online collaboration platforms like “Xuexitong,” to support data coupling and analysis; and 3) shared project repositories and design templates to lower the implementation threshold for instructors. It is recommended to systematically promote necessary faculty development through initiatives such as establishing “Complex Engineering Course Design” workshops, forming NPBL teaching practice communities, and recognizing exemplary NPBL courses as outstanding teaching achievements.

### 7.3 Conclusions

The NPBL model, through its nested project structure and dual-cycle progressive process, successfully creates an authentic complex engineering practice context within a single “Transportation Planning” course. Through the iteration of “decomposition-integration,” students actively construct knowledge connections, effectively transforming the cultivation of complex systems thinking from an educational philosophy into observable and assessable teaching practices. Empirical data from two complete instructional cycles confirm the model’s effectiveness in promoting students’ knowledge integration and higher-order thinking skills, offering new insights for the in-depth reform of engineering education within the context of Emerging Engineering Education. However, the implementation of this teaching model also presents new challenges for both instructors and students. Therefore, further research and practice are needed in developing supporting NPBL design templates and case libraries to lower the design threshold for instructors, forming interdisciplinary teaching teams to jointly address multidisciplinary issues arising in complex projects, and reforming instructor evaluation mechanisms to recognize their substantial efforts in course design and process guidance.

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