

# Research on the Innovative Path of Industry-Education Integration in Engineering Industry Colleges under the Background of New Engineering

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**Abstract:** *The construction of New Engineering has imposed requirements on engineering talent cultivation, demanding a transformation from a single technical specialty to composite engineering capability and systematic thinking. As the core carrier of industry-education integration, engineering industry colleges urgently need structural innovation in their education paths. This study starts with the deconstruction of the industry-education integration mechanism, identifies the heterogeneous elements and their relational network topological characteristics between the academic cultivation system and the industrial technology system within engineering industry colleges, and analyzes the fracture points of the traditional linear series connection model, which are concentrated at the levels of knowledge transfer and capability transformation. On this basis, the study proposes the reshaping logic of the education path, constructs a curriculum system embedded design based on the full cycle of engineering projects, a flexible transformation mechanism of teaching organization driven by the dual subjects of the university and the enterprise, and a collaborative education model coupling knowledge flow with technological iteration. Furthermore, this study designs a multi-node feedback regulation system to achieve near real-time response of the path operation status, establishes a dynamic mapping model between the engineering capability map and the cultivation process to enhance capability specificity, and proposes a hierarchical migration strategy for the continuous evolution of the path from the perspective of the ecological niche. This research provides a systematic methodological framework for the innovative construction and dynamic optimization of the industry-education integration education path in engineering industry colleges.*

**Keywords:** *New Engineering; engineering industry colleges; industry-education integration; education path; capability map; ecological niche*

## Introduction

Under the background of New Engineering, engineering education faces the dual pressures of an accelerated update of the knowledge system and a shortened iteration cycle of industrial technology. The traditional model of organizing teaching based on disciplinary logic can hardly meet the demand for cultivating the ability to solve complex engineering problems. As special educational units connecting the academic cultivation system and the industrial technology system, engineering industry colleges have their effectiveness in the industry-education integration education path directly determining the degree of capability matching of engineering talents. Current industry-education integration often falls into formalized cooperation at the operational level. The substantive integration between universities and enterprises in such links as curriculum co-construction, project training, and capability assessment remains insufficient, resulting in problems such as knowledge transfer fragmentation and capability transformation delay. Therefore, it is necessary to conduct a systematic review and innovative design of the industry-education integration education path in engineering industry colleges. The necessity of this study is reflected in two aspects: first, responding to the requirements of New Engineering for reconstructing the capability structure of engineering talents; second, solving the inherent defects of link fragmentation and slow response in the traditional industry-education integration path. Through progressive research at the three levels of mechanism deconstruction, architecture design, and dynamic optimization, this study aims to construct a set of adaptive and iterable innovative solutions for the industry-education integration education path, thereby

providing theoretical support and operational basis for engineering industry colleges to enhance their educational effectiveness.

## **1. Deconstruction and Reconstruction of the Industry-Education Integration Education Mechanism in Industry Colleges**

### ***1.1 Element Identification and Relationship Network of Industry-Education Integration in Engineering Industry Colleges***

The industry-education integration mechanism of engineering industry colleges involves the interaction of multiple heterogeneous elements. The integration elements include engineering knowledge systems, industrial technology standards, engineering training equipment, university-enterprise dual-track teaching staff, and project-based learning tasks. These elements respectively belong to the academic cultivation system and the industrial technology system. The two systems have inherent differences in goal orientation, resource allocation, and evaluation criteria, which often leads to asymmetric coupling characteristics among the elements. Effectively identifying the functional attributes of each element and their weights in the education process constitutes the basic step for constructing the industry-education integration relationship network<sup>[1]</sup>.

The topological structure of the relationship network determines the transmission efficiency of information flow and task flow among the elements. From the perspective of network nodes, students, university teachers, enterprise engineers, course modules, engineering projects, and training platforms jointly constitute a set of multiple nodes. The nodes form a dynamic network through such edges as curriculum co-construction, technological problem-solving, and joint supervision. In this network, the connection density between enterprise technology nodes and course content nodes directly affects the transmission accuracy of engineering capabilities, while management nodes (such as the teaching guidance institution of the industry college) play a role in regulating network stability. Through the analysis of node connectivity and centrality, one can identify the key hubs and weak links in the network, thereby providing quantitative basis for subsequent path reconstruction.

### ***1.2 Limitations and Fracture Point Analysis of the Traditional Industry-Education Integration Education Path***

The traditional industry-education integration education path mostly adopts a linear series connection model, which is advanced in the order of "basic courses, professional courses, enterprise internships, and graduation projects". This path lacks closed-loop feedback among its various links, and the update of course content lags behind the iteration speed of industrial technology, resulting in students facing a structural mismatch between knowledge and skills when they enter the enterprise internship stage. Under the traditional path, engineering industry colleges often have substantive interaction between the university and the enterprise only in the internship and employment links, while their depth of participation in the front-end links such as curriculum design, project training, and capability assessment is limited, thus forming functional islands in the education chain<sup>[2]</sup>.

Further analysis of the fracture points in the path mainly focuses on two key levels: knowledge transfer and capability transformation. The fracture of knowledge transfer manifests as significant differences in complexity, constraints, and openness between the problem situations used in on-campus theoretical teaching and the real technical problems on engineering sites, making it difficult for students to map symbolic knowledge into actionable engineering decisions. The fracture of capability transformation is reflected in the disconnect between project training and industrial standards, as exemplified by the lack of comprehensive consideration of cost control, reliability, and technical economy in students' course designs. The above-mentioned fracture points cause industry-education integration to degenerate into formal cooperation rather than substantive educational integration, thereby weakening the educational effectiveness of engineering industry colleges.

### ***1.3 The Reshaping Logic of the Education Path Driven by New Engineering***

Under the background of New Engineering, the core demand of engineering talent cultivation has shifted from a single technical specialty to composite engineering capability and systematic thinking. This shift requires the education path of industry colleges to be upgraded from a linear series connection structure to a multilateral coupling structure. The primary task of the reshaping logic is to

reconstruct the demand transmission mechanism: the industrial technology capability model is broken down into micro-units that can be embedded into courses and projects, and the dynamic reorganization between knowledge units and skill units is achieved through modular design. On this basis, the education path no longer presets a fixed sequence; instead, it constructs a personalized progression map according to learning progress and project complexity, allowing students to repeatedly move back and forth between theoretical learning and engineering practice at different stages.

Another piece of reshaping logic is reflected in the transformation of the evaluation system from summative assessment to pervasive capability mapping. In the traditional path, each link is evaluated independently and the results are not interconnected; after reshaping, the path requires the establishment of a unified engineering capability growth portfolio, which records students' performance data in course learning, simulation training, engineering projects, and technical problem-solving, and generates dynamic feedback through the matching degree between capability indicators and industrial job standards. This logic effectively bridges the fracture points mentioned above, shifts industry-education integration from experience-oriented to data-driven, and provides an iterative education path construction method for industry colleges<sup>[3]</sup>.

## **2. Multidimensional Architecture Design of Path Innovation**

### ***2.1 Embedded Design of the Curriculum System Based on the Full Cycle of Engineering Projects***

The full cycle of an engineering project covers such stages as demand analysis, scheme design, detailed design, test verification, deployment, and operation and maintenance. Each stage corresponds to a specific combination of engineering knowledge and skills. The embedded design maps the above stages into the organizational logic of course modules, so that the curriculum system is no longer a static list classified by disciplines but a set of knowledge units dynamically configured according to the project evolution timeline. Specifically, the project initiation stage embeds courses in requirements engineering and system modeling; the design and verification stage embeds courses in computational simulation and reliability analysis; and the operation and maintenance stage embeds courses in fault diagnosis and efficiency optimization. The interface standards and prerequisite dependencies among the course modules are defined according to the actual input-output of each project stage, thereby eliminating knowledge redundancy and articulation gaps caused by disciplinary boundaries in the traditional curriculum system.

The embedded design also requires a bidirectional coupling relationship between the course content and the project stages. On the one hand, project progress triggers the activation of corresponding course modules, allowing students to acquire theoretical knowledge on demand while completing project tasks. On the other hand, the technical methods taught in the courses iteratively optimize the project implementation plans, forming a closed-loop iteration of teaching and doing. To support this coupling, the curriculum system needs to set up pluggable micro-course units, each corresponding to a key technical activity in a certain stage of the project, such as parameter identification, error analysis, or robust design. These micro-units are not fixed to specific semesters but are dynamically scheduled according to project milestones, thereby realizing the transformation of the curriculum system from a static structure to a process-responsive structure.

### ***2.2 The Flexible Transition Mechanism of Teaching Organization Driven by the Dual Subjects of University and Enterprise***

The core of the dual-subject drive of the university and the enterprise lies in breaking the rigid constraints of a single teaching organization form and establishing an organizational architecture that can smoothly switch among the university-led mode, the enterprise-led mode, and the collaborative governance mode. Under the university-led mode, the teaching organization takes the disciplinary knowledge system as its backbone, and the course sequence follows the law of cognitive progression. Under the enterprise-led mode, the teaching organization takes the engineering project delivery plan as its pace, and learning activities are unfolded according to the work breakdown structure. Under the collaborative governance mode, the teaching organization is coordinated by a joint teaching guidance unit of the university and the enterprise, which dynamically allocates teaching tasks based on capability achievement levels and resource availability. The flexible transition mechanism requires the preset transition trigger conditions at the organizational level. For example, when the deviation between the course content and the industrial technology standard exceeds a set threshold, the system automatically

switches to the enterprise-led mode for content calibration<sup>[4]</sup>.

The operation of the transition mechanism relies on a configurable resource pool and a role authority and responsibility mapping table within the teaching organization. The resource pool includes university teachers, enterprise engineers, training equipment, software tools, and project datasets. Each resource is encoded with tags based on teaching scenarios, facilitating rapid reorganization under different modes. The role authority and responsibility mapping table clearly defines the decision-making authority, execution tasks, and evaluation responsibilities of university teaching nodes and enterprise technology nodes in each mode. When the organizational mode switches, the system automatically adjusts the approval flow, task allocation, and quality gate settings according to the mapping table. This flexible transition mechanism enables the industry college to select an appropriate organizational form based on the course type, project stage, and student capability level without interrupting the teaching process, thereby avoiding resource idleness or teaching mismatch caused by mode rigidity.

### ***2.3 Construction of a Collaborative Education Model Coupling Knowledge Flow with Technological Iteration***

Collaborative education refers to a model of education in which the university and the enterprise conduct in-depth cooperation in the talent cultivation process, jointly formulate cultivation plans, organize teaching activities, and provide educational resources, so as to achieve a precise match between talent supply and industrial demand. The design goal of this model is to convert the technological iteration pulses from the industrial side into the update rhythm of the teaching content on the university side. The core component of this model is the knowledge conversion gateway, which receives problem reports, process change records, and new technology verification data from the enterprise's technical department, and generates teachable knowledge units after structured processing. For example, the tolerance accumulation problem encountered by an enterprise in new product trial production can be abstracted into a teaching case on geometric dimensioning and tolerance analysis, accompanied by original data, constraint conditions, and failure mode analysis. This process achieves the conversion of tacit knowledge into explicit knowledge while maintaining the engineering authenticity of the technical problem.

Another key link in the construction of the model is the establishment of a bidirectional iteration channel, which not only allows the one-way injection of industrial technology into the teaching side but also supports the optimization schemes generated by the teaching side to feed back into industrial technology iteration. In the specific design, alternative technical paths, parameter optimization methods, or test improvement schemes proposed by students when completing course projects or graduation designs, after being reviewed by the joint university-enterprise technical review, can be incorporated into the enterprise's technical change process if verified as effective. This channel requires the setting of a technology readiness assessment module, which classifies technical achievements from different sources into levels, and only allows schemes that reach a specific level to enter the industrial application link. Through the coupling of knowledge flow and technological iteration, collaborative education is no longer a simple static transfer of knowledge but evolves into an innovative New Engineering education model with feedback amplification functionality.

## **3. Operational Guarantee and Dynamic Optimization of Path Innovation**

### ***3.1 Multi-Node Feedback Regulation System for the Industry-Education Integration Education Path***

The multi-node feedback regulation system uses the course modules, project nodes, capability assessment points, and university-enterprise interaction points in the education path as feedback collection nodes to construct a closed-loop regulation network covering the entire cultivation process. Each node is equipped with a standardized data collection interface to capture students' learning behavior parameters, task completion quality indicators, and university-enterprise collaboration efficiency indicators. For example, the course module node collects knowledge mastery and learning engagement duration; the project node collects technical solution review scores and iteration counts; and the university-enterprise interaction node collects technology demand response latency and knowledge conversion success rates. After normalization processing, these multi-source heterogeneous data are aggregated into the path regulation engine to form a quantitative description of the current path operation status<sup>[5]</sup>.

The regulation engine has a built-in deviation detection algorithm, which compares the real-time data with the preset path performance baseline curve and identifies the specific nodes and deviation types where the deviation exceeds the threshold. According to the nature of the deviation, the system can trigger different levels of regulation actions: intra-node regulation is achieved by adjusting the teaching resource allocation or task difficulty of that node, while inter-node regulation is completed by modifying the connection weights between preceding and following nodes or reallocating the node sequence. The regulated path status then re-enters the data collection cycle, forming a continuous convergence feedback process. The design of this system enables the industry-education integration education path to no longer rely on summative evaluations at the end of the year or semester, but to possess near real-time response capability, dynamically eliminating deviation accumulation within the cultivation cycle.

### ***3.2 Dynamic Mapping Model Between the Engineering Capability Map and the Cultivation Process***

The engineering capability map is a structured representation of the engineering capabilities required by the industry, containing capability dimensions, capability units, and the dependency relationships among the capability units. The capability dimensions are divided into technical operation capability, engineering analysis capability, system integration capability, and technological innovation capability. Each dimension is further decomposed into observable capability units; for example, technical operation capability includes units such as instrument operation, code writing, and parameter tuning. Prerequisite and successor relationships are defined among the capability units, forming a directed acyclic graph structure that reflects the inherent cognitive order and skill accumulation logic of engineering capability formation. The task of the dynamic mapping model is to project the trajectory of students' learning activities in the industry-education integration path onto this capability map in real time, generating such indicators as individual and group capability coverage, capability achievement depth, and deviation of the capability development path.

The operation of the mapping model relies on a rule base of associations between capability indicators and the characteristics of teaching activities. Each rule defines the contribution weight and confidence level of a specific teaching activity (such as completing the design report of a certain engineering project stage) to a particular capability unit. When the behavioral data collected by the student through the multi-node feedback regulation system satisfies the rule trigger conditions, the model automatically updates the student's state value on the corresponding capability unit. The accumulated state values form a capability heat map, which can be used to identify capability weaknesses and redundant cultivation links. Furthermore, the model supports reverse mapping: given a desired cross-section of the capability map, one can reversely derive the required combination of teaching activities and path sequence. This bidirectional mapping capability transforms the cultivation process from experience-based content arrangement to target-state-based path planning, thereby enhancing the engineering capability specificity of talent cultivation in industry colleges.

### ***3.3 Continuous Evolution Strategy of the Path from the Perspective of the Industry College's Ecological Niche***

The ecological niche perspective regards the industry college as a functional unit embedded in the regional engineering technology ecosystem, and the survival and development of its education path depend on resource exchange and functional complementarity with other ecological units (including industrial enterprises, technical service institutions, professional certification organizations, etc.). The core of the path continuous evolution strategy is to construct an ecological niche monitoring and migration mechanism. By periodically collecting the technological distribution density of the surrounding industrial technology communities, the talent demand spectrum, and the path characteristics of similar educational institutions, the system determines the current ecological niche coordinates of the college. When the ecological niche overlap is too high or the availability of technological resources declines, it indicates that the existing education path faces the risk of homogeneous competition or resource depletion, thus requiring the initiation of the path evolution process.

The evolution program adopts a hierarchical migration strategy. The first level involves intra-path parameter optimization, which adjusts course module weights, node thresholds, or feedback gain coefficients without changing the topological structure of the path. The second level involves path structure fine-tuning, which achieves local reconstruction of the path topology by adding or deleting several nodes or modifying the connection modes between nodes. The third level involves path

paradigm transformation, corresponding to a fundamental migration of the ecological niche, such as shifting from a path oriented to general engineering positions to a narrow-spectrum and deep-path oriented to specific technical domains (such as intelligent control systems or high-end equipment integration). The three-level strategy is sorted in ascending order of cost and risk, and the corresponding level is selected based on the degree of ecological niche deviation and the prediction results of technology trends. This evolution strategy endows the education path of the industry college with ecological adaptability, avoiding the functional rigidity and value decay of the path caused by changes in the industrial technology environment.

## Conclusion

This study focuses on the innovative path of industry-education integration in engineering industry colleges under the background of New Engineering, and completes a three-level research from mechanism deconstruction to architecture design and then to operational guarantee. First, this study identifies the heterogeneous elements and their relationship network in industry-education integration, clarifies the fracture points of the traditional path, and proposes a reshaping logic centered on the reconstruction of the demand transmission mechanism and the transformation of the evaluation system. Second, this study designs an embedded curriculum structure based on the full cycle of engineering projects, a flexible teaching organization transition mechanism driven by the dual subjects of the university and the enterprise, and a collaborative education model with feedback amplification functionality, forming a multidimensional architectural path innovation scheme. Finally, this study constructs a multi-node feedback regulation system, a dynamic mapping model of the engineering capability map, and a hierarchical evolution strategy based on ecological niche monitoring, providing a guarantee mechanism for the continuous optimization of the path. Future research directions can be developed from the following aspects: first, exploring algorithmic paths for the automatic construction and update of the capability map to reduce reliance on manual annotation rules; second, studying the mechanism of ecological niche comparison and collaborative evolution of cross-regional industry colleges to verify the applicability of the hierarchical migration strategy in different technological communities; third, developing an information support platform that supports the above multi-node feedback and dynamic mapping to realize the digital twin and simulation deduction of the education path operation.

## Fund Projects

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