Education Reform and Development, 2026, Volume 8, Issue 2
https://ojs.bbwpublisher.com/index.php/ERD
Online ISSN: 2652-5372
Print ISSN: 2652-5364

Research on the Construction and Practical Path of the Collaborative Education Mechanism for Postgraduate Outstanding Engineers from the Perspective of Industry-Education Integration

Dongye Zhao, Sijun Fang, Hongwen Hai

School of New Energy, Inner Mongolia University of Technology, Hohhot 010051, Inner Mongolia, China

Abstract: Facing the demand for cultivating high-level engineering talents under the background of the new industrialization, the reform of postgraduate engineering education is in urgent need of solving the practical dilemma of "structural mismatch between the training supply side and the industrial demand side". Based on postgraduate education and teaching reform projects and the theoretical framework of "Demand Signal Transmission - Resource Collaborative Allocation - Capacity Iterative Evolution", this study proposes a collaborative education mechanism featuring "demand orientation, multi-subject collaboration and dynamic feedback", and constructs a practical closed loop of "enterprise-proposed topics - university-solved problems - joint acceptance" with enterprise technological research projects as the carrier. The study further puts forward the implementation path of "curriculum system reconstruction + project-based practice + enterprise tutor system", supported by institutional guarantees such as the "modular + project-based" teaching organization mode, practice achievement credit system, enterprise tutor evaluation weight system and university-enterprise joint evaluation committee, to realize the transformation of postgraduate training quality from "result-oriented academic output" to "dual capability orientation of academic and engineering competence". This research provides operable mechanism design and path reference for local engineering colleges and universities to promote the collaborative education of postgraduate outstanding engineers in industrial agglomeration areas.

Keywords: Industry-education integration; Outstanding engineers; Postgraduate training; Collaborative education mechanism; Closed-loop evaluation

Online publication: March 31, 2026

1. Introduction

One of the core problems in the reform of engineering education is the significant time lag between the speed of industrial technological iteration and the update cycle of university curriculum systems, which results in postgraduates needing a long period of "re-training" after entering enterprises. As pointed out in the project application, this problem is mainly manifested in the lagging curriculum system, the disconnection between practical links and real enterprise scenarios, and the deviation of evaluation mechanisms from the engineering competence orientation. Furthermore, from the perspective of university-enterprise cooperation practice, “insufficient enterprise participation motivation, single function of practical platforms, and deviation of evaluation orientation from the essence of engineering” constitute the typical bottlenecks of the reform. Against this background, how to realize the effective “visualization - translation - evaluation” of industrial demands at the postgraduate training level and form a long-term mechanism for university-enterprise collaboration is a key question to be answered urgently.

2. Review of relevant research and theoretical orientation

Existing research on engineering education reform mostly demonstrates the importance of university-enterprise cooperation from the perspective of necessity and macro policies, but lacks “operable modeling” of the internal mechanism of collaborative education. The project application points out that although Germany’s Dual System emphasizes enterprise leadership and alternating work and study, its standardized path of vocational qualification framework is difficult to be directly transferred to the cultivation of postgraduate innovation capabilities [1]; the university-enterprise joint laboratory of MIT in the United States highlights the research orientation, but fails to systematically solve the dynamic adaptation between the curriculum system and industrial demands [2]. At the same time, models such as OBE and CDIO provide instrumental frameworks for teaching design, but there are still deficiencies in connecting the whole chain of “industrial demand identification - educational resource integration - training quality feedback” [3]. Therefore, this study tends to reconstruct the postgraduate collaborative education mechanism from the perspective of system theory: it is necessary to explain “how demands enter the training system” and answer “how resources are allocated to form a closed loop of capability improvement”.

3. Research design and overall framework

3.1. Overall logic and research ideas

This study follows the logical main line of “problem orientation - theoretical construction - practical verification - iterative optimization”, emphasizes “engineering drives design, and design drives scientific research”, and designs the training process through industrial pain points to form a dynamic closed-loop research and practical path. At the mechanism model level, a framework of “Demand Signal Transmission - Resource Collaborative Allocation - Capacity Iterative Evolution” is constructed: starting with the identification and translation of industrial demand signals [4], the reorganization of training elements is realized through the collaborative allocation of resources by multiple subjects including universities, enterprises and the government, and finally continuous improvement is formed with the evidence chain of capacity iteration.

3.2. Practical closed loop: Enterprise-proposed topics - university-solved problems - joint acceptance

To avoid the superficialization of “university-enterprise cooperation staying at the level of practice bases and lectures”, this study takes enterprise technological research projects as the carrier to form a practical closed loop of “enterprise-proposed topics - university-solved problems - joint acceptance”. The key is to transform the enterprise’s demand description into teachable, assessable and deliverable task packages, including demand boundaries, engineering constraints, indicator systems, interface specifications and acceptance checklists, thus placing “real engineering problems” in the whole process of training [5].

4. Collaborative education mechanism and implementation path

4.1. Mechanism 1: Demand-oriented “Signal transmission” mechanism

Demand signal transmission emphasizes translating industrial demands from “oral experience” into “structured elements” and updating them continuously. The project application proposes to sort out the blocking points through enterprise exchanges, student surveys, industry forum discussions and other methods, and use the industrial technology map analysis method to draw the technical demand map of key fields to clarify the core competence standards for engineers [6]. In the context of postgraduate training, the implementation starting points of this mechanism include:

(1) Structured expression of enterprise demands, i.e., the improvement of demand documentation, indexation and interface standardization.

(2) Mapping rules between demands and courses/projects, mainly reflected in the corresponding relationship of “demand items - capability items - teaching modules - evaluation evidence” [7].

(3) Feedback mechanism for demand update, which requires the iteration of the demand database driven by joint acceptance and review.

4.2. Mechanism 2: Multi-subject “Resource collaborative allocation” mechanism

Resource collaborative allocation is not only “university-enterprise cooperation”, but also reconstructs the ecological relationship from the perspective of the “four-chain collaboration” of education chain, industrial chain, innovation chain and talent chain, forming a collaborative education ecosystem with multiple subjects such as universities, enterprises and the government [8]. The specific allocation methods can be expressed as:

(1) Curriculum resources: Integration of on-campus courses with enterprise standards and enterprise case databases.

(2) Practical resources: Coupling of university-enterprise joint laboratories/engineering practice platforms with on-site enterprise tasks.

(3) Tutor resources: Role division and key node intervention of on-campus tutors (academic) and enterprise tutors (engineering).

(4) Evaluation resources: Institutional embedding of the joint evaluation committee and the process data evidence chain.

4.3. Mechanism 3: Competence-oriented “Iterative evolution” mechanism

The core of capacity iterative evolution is to drive continuous improvement with closed-loop evidence. The project application clearly proposes to build a closed-loop training system of “demand definition - experimental design - practical verification - evaluation optimization”.

In terms of evaluation philosophy, we can learn from the process and the competence-oriented evaluation proposed in the sample papers and form a closed-loop learning ecosystem of “evaluation - feedback - improvement” [9]. Therefore, capacity iteration is not “students doing a project one more time”, but continuously optimizing teaching modules and task design through the analysis of process data and achievement evidence to realize the “self-correction” of the training system [10].

5. Teaching organization and evaluation system design

5.1. Implementation path of "Curriculum system reconstruction + Project-based practice + Enterprise tutor system"

The project abstract proposes to take the cultivation of outstanding engineers as the core, form an industry-education integration implementation path of "curriculum system reconstruction + project-based practice + enterprise tutor system", and establish an evaluation system centered on engineering practice competence [11]. Based on this, this study organizes the training links into three stages:

(1) Curriculum modularization stage: Organize curriculum content around key engineering competencies.

(2) Project-based practice stage: Organize practice with enterprise project task packages.

(3) Joint acceptance and review stage: Organize achievement evaluation and reflection with enterprise acceptance checklists and academic refinement requirements.

5.2. "Modular + Project-based" teaching organization mode

The application emphasizes the adoption of the "modular + project-based" mode, integrating enterprise technical standards into engineering design and allowing students to participate in the whole process of product research and development [12]. Modularization emphasizes the combinability of competence units; project-based learning emphasizes the authenticity and deliverability of task chains. The combination of the two can realize:

(1) Shifting from "knowledge point explanation" to "engineering task chain drive".

(2) Shifting from "one-time presentation" to "multi-version iteration and continuous verification".

(3) Shifting from "experience-based evaluation" to "evidence-based evaluation".

5.3. Evaluation and institutional guarantee: Dual assessment of academic and engineering competence

The project proposes to break the tendency of "valuing only papers", introduce the "practice achievement credit system" and "enterprise tutor evaluation weight system", and explore the form of a university-enterprise joint evaluation committee to realize the dual assessment of "academic" and "engineering" competence [13].

On this basis, the evaluation framework can be designed as:

(1) Process evaluation: Emphasizing learning input, iteration records and collaborative contributions.

(2) Engineering evaluation: Emphasizing indicator achievement, test reports and reproducible delivery.

(3) Academic evaluation: Emphasizing the refinement of models/methods and achievements such as papers/patents/software copyrights.

At the same time, referring to the discussion on dynamic and multi-dimensional evaluation in the sample papers, process data is incorporated into the evaluation basis, shifting from "single result evaluation" to "whole-process development evaluation".

6. Presentation of practical effects and verifiable indicators

Considering that the common review focus of educational reform papers is "verifiability", it is suggested to present the phased effects in the final draft in the form of "indicator - evidence - source" [14] (even if large-sample statistics have not been formed yet, process evidence and typical cases can be presented). For example:

(1) Standardization of enterprise demand translation

Core indicators include the completeness rate of demand documents, coverage rate of acceptance checklists, and correspondence integrity between demands and courses; process evidence includes initial demand documents provided by cooperative enterprises, teaching instruction manuals revised through university-enterprise cooperation, project acceptance checklists and teaching objective forms. The main sources of evidence are records of university-enterprise joint teaching and research activities, minutes of university-enterprise cooperation meetings, archived records of online platforms, and curriculum syllabus revision manuals.

(2) Quality of engineering delivery

Core indicators include the standardization of test reports, completeness of reproducible materials, compliance rate of code/documents, and compliance rate of delivered achievements; process evidence is reflected in students' project test reports, reproducible experiment records in project repositories, and enterprise acceptance feedback records; sources of evidence include project conclusion materials, enterprise evaluation opinion records, and platform data such as GitLab/GitHub [15].

(3) Evidence of capacity improvement

Core indicators include stage review records, abstracts of enterprise tutor evaluations, and key competence items; process evidence includes mid-term and final defense records, enterprise tutor evaluation forms, student self-evaluation forms, and student peer evaluation data; sources of evidence are process evaluation files, enterprise tutor evaluation records, and student questionnaire survey data.

(4) Academic transformation capacity

Core indicators are the number of research questions abstracted from project tasks, phased paper/patent clues, and the correlation between academic achievements and engineering tasks. Evidence includes research question refinement forms, paper drafts, patent application manuscripts, and PPTs for academic seminar reports; sources of evidence are research and discussion records of research groups, academic achievement materials, and abstracts of academic achievements.

7. Discussion: Difficulties and countermeasures in the implementation of the mechanism

The project application has pointed out three practical bottlenecks: insufficient enterprise participation motivation, single function of practical platforms, and deviation of evaluation orientation from the essence of engineering.

This study further refines them as follows:

(1) High cost of demand expression: Enterprises need to invest engineers' time in "proposing topics". It is suggested to reduce communication costs through demand templates and case databases.

(2) Unclear tutor role boundaries: The intervention of enterprise tutors should not be generalized, but should be fixed at the key nodes of demand clarification, mid-term review, and joint acceptance.

(3) Non-unified evaluation criteria: It is suggested to form a common evaluation criterion for "academic and engineering competence" in the form of a joint evaluation committee.

8. Conclusions and prospects

Based on the framework of "Demand Signal Transmission - Resource Collaborative Allocation - Capacity Iterative Evolution", this study constructs a collaborative education mechanism for postgraduate outstanding engineers, and puts forward an operable implementation path of "curriculum system reconstruction + project-based practice + enterprise tutor system" and an institutional evaluation scheme. Future research will be deepened around two directions: first, improving the coupling method between the industrial technology demand map and the talent training competence matrix to enhance the accuracy of demand translation; second, introducing digital and intelligent means to form a dynamic evaluation model to realize the continuous tracking of lifelong learning ability from knowledge mastery.

Funding

Postgraduate Education and Teaching Reform Project of Inner Mongolia University of Technology, "Research on the Innovation of Collaborative Education Mechanism for Outstanding Engineers from the Perspective of Industry-Education Integration" (Project No.: RC2500001598); 2025 Initiation Project of Inner Mongolia University of Technology (Project No.: DC2500002532); Exploration of the Teaching Model of Mechanical Design under the Background of New Energy (Project No.: RC2500004419); 2025 Initiation Project of Inner Mongolia University of Technology (Project No.: DC2500002545); 2025 Initiation Project of Inner Mongolia University of Technology (Project No.: DC2500002546)

Disclosure statement

The authors declare no conflict of interest.

References

[1] Ji R, Guo H, 2024, Realistic Dilemmas and Relief Strategies of University-Enterprise Collaborative Cultivation of Outstanding Engineers from the Perspective of the Interactive Ritual Chain Theory. Heilongjiang Researches on Higher Education, 44(01): 69–75.

[2] Chen GY, Cai H, Lu ZS, et al., 2024, Analysis of the Industry-Education Integration Training Path for Outstanding Engineers from the Perspective of "Elite Education" — A Case Study of Engineering Doctor Education. Journal of Tianjin University (Social Sciences), 27(06): 490–498.

[3] Song YD, 2024, Constructing an Industry-Education Integration Training System for Outstanding Engineering Talents with "Four-Chain Collaboration". China Higher Education, 2024(19): 41–45.

[4] Gan YT, Yuan J, 2024, Symbiotic Dilemmas and Solving Strategies of Industry-Education Integration Training for Outstanding Engineers. Academic Degrees & Graduate Education, 2024(08): 35–42.

[5] Shi YK, Wang M, 2024, How to Achieve the Expected Results in the Cultivation of High-Level Outstanding Engineers? — A Study Based on Content Analysis and fsQCA Method. Journal of Higher Education Management, 19(04): 111–124.

[6] Han FH, Wang Z, Lin SY, et al., 2024, Research on the Training System for Marine-Related Outstanding Engineers under the "One-Core, Two-Wing and Three-Integration" Collaborative Education Model. University Education, 2024(05): 117–121.

[7] Zhang HJ, Ma C, Wei X, et al., 2024, Exploration and Practice of the Cultivation of Outstanding Engineer Talents under the University-Enterprise Collaborative Education Model. University and Discipline, 5(04): 68–75.

[8] Zhao WS, 2024, Promoting the Reform of Industry-Education Integration Training for Outstanding Engineers with

"Three Organized Initiatives". China Higher Education, 2024(22): 29–33.
[9] Zhou DC, Yang F, Liu X, et al., 2024, Exploration and Practice of University-Enterprise "Dual-Core Collaboration" in the Cultivation of Engineering Postgraduates. Academic Degrees & Graduate Education, 2024(10): 54–60.
[10] Ma LJ, Zhang H, XuT, et al., 2024, Exploration of an Innovation Talent Training Community in Research Universities from the Perspective of Industry-Education Integration — A Case Study of the Science and Technology Industry Education Practice of Tongji University. Science and Technology Entrepreneurship Monthly, 37(01): 154–160.
[11] Zhang HL, Yang HW, Chai CZ, 2023, Research on the Collaborative Education Mechanism of On-Campus Tutors, Enterprise Tutors and Counselors — A Case Study of the Cultivation of Outstanding Engineers in the Information and Communication Field. Industry and Information Technology Education, 2023(09): 60–64.
[12] Li YX, 2023, Research on the Industry-Education Integration Collaborative Training Mechanism for Engineering Doctors in China. Huazhong University of Science and Technology, 1–x.
[13] Zhang TT, Li C, 2023, Relationship and Path: A Study on the Action Logic of Cultivating Outstanding Engineers through Industry-Education Integration. China Higher Education Research, 2023(05): 48–54.
[14] Ren YQ, 2022, Research on the Industry-Education Integration Collaborative Education Mechanism under the Background of Emerging Engineering Education, thesis, East China Normal University.
[15] Zhao CH, 2019, Research on the Industry-Education Integration Education Model under the Background of Emerging Engineering Education, thesis, Xidian University.