

PRACTICE EXPLORATION OF INDUSTRY-EDUCATION INTEGRATION AND COLLABORATIVE EDUCATION FOR ENGINEERING MANAGEMENT UNDER THE NATIONAL FIRST-CLASS PROGRAM CONSTRUCTION

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Abstract: Driven by national “First-class Undergraduate Program” initiatives and engineering accreditation, engineering management education in China must evolve from fragmented course assembly to a system-oriented approach. Addressing the common bottlenecks of weak measurability of goals, shallow school–enterprise cooperation, fragmented practice scenarios, and incomplete assessment loops, this study proposes a four-chain collaborative model—Goal Chain, Curriculum Chain, Practice Chain, and Assessment Chain—grounded in outcomes-based education (OBE). The model aligns policy and industry needs to produce a competency profile and indicator matrix, restructures curriculum clusters and resources to enable project-based learning and real-industry task embedding, builds tiered practices with dual-supervisor mentoring across campus–enterprise bases and unified digital toolchains, and implements evidence-centered assessments with rubrics, attainment thresholds, and early-warning dashboards to close the quality-improvement loop. A three-year implementation shows significant gains in students’ competencies in digital construction (BIM), contract and risk governance, process control, and collaborative communication; increased involvement of industrial mentors; faster course updates; and improved graduate employability and job fit. The results demonstrate a viable pathway of “evidence for improvement, projects for capability, collaboration for quality,” offering a replicable solution for first-class program construction in engineering management.

Keywords: Engineering management; First-class undergraduate program; Industry–education integration; Collaborative education

1 INTRODUCTION

Situated at the nexus of engineering technology and management science, the quality of talent cultivation in the engineering management major directly influences the high-quality development of infrastructure and the construction industry. Under the combined traction of emerging engineering education, first-class undergraduate program construction, and engineering education accreditation, program objectives have gradually shifted toward a composite capability framework of “strong engineering literacy, proficient in management methods, literate in digital technologies, and adept at collaborative governance.” However, practical bottlenecks persist, including macro-level and weakly measurable goal statements, shallow and fragmented industry–education collaboration, and evaluations that substitute process for outcomes. From an industry trend perspective, agendas such as whole-process engineering consulting, digital construction and BIM collaboration, green and low-carbon strategies under the dual-carbon goals, urban renewal, and improved infrastructure resilience are rapidly reshaping project organization and governance capabilities[1]. Job requirements increasingly emphasize problem framing in complex contexts, data-driven decision-making, contract and risk governance, cross-disciplinary collaboration, and integrated application of tools such as BIM, GIS, and IoT. In response, this paper—guided by the OBE philosophy and policy orientation—proposes and implements a systematic talent cultivation model of “Four-Chain Collaboration,” delivering a holistic solution of “measurable goals, restructured curriculum clusters, project-based practice, and evidence-centered evaluation.” The aim is to connect the loop of “goals–implementation–evaluation–improvement” and to provide a replicable pathway and experience for peer institutions.

2 POLICY AND THEORETICAL FOUNDATIONS: FROM BENCHMARKING TO PROFILING

At the policy level, the “Double Ten-Thousand Plan” promotes connotative development of programs; engineering education accreditation strengthens student-centeredness, outcome-orientation, and continuous improvement; and policies on industry–education integration and collaborative education transform enterprises from external supporters into co-educators. Thus, the key to first-class program construction lies in a dual drive of “standardization + differentiation”: benchmarking national and industry standards to guarantee baselines and common quality while

building a differentiated competency profile grounded in regional industrial structures and institutional strengths. Theoretically, OBE advocates backward design from intended outcomes, decomposing graduation requirements into observable and assessable indicators and implementing them via precise mapping of course objectives and learning activities. Situated learning and project-based learning emphasize knowledge construction through authentic or quasi-authentic tasks, social collaboration, and tool use—highly consistent with the contextual and collaborative nature of engineering projects[2].

Based on interviews with housing and urban–rural development authorities, consulting firms, and construction enterprises, this study forms a competency profile for engineering management: foundational competencies include engineering cognition, digital literacy, professional ethics, and communication; core competencies include integrated control of schedule–cost–quality, contract and risk management, BIM and digital construction applications, bidding and claims; integrative competencies highlight cross-disciplinary collaboration, decision-making in complex contexts, and organizational leadership. This profile anchors the indicator points of graduation requirements and serves as the basis for curriculum cluster restructuring, practice system organization, and rubric design.

3 MODEL CONSTRUCTION AND IMPLEMENTATION PATH: SYSTEM DESIGN OF FOUR-CHAIN COLLABORATION

The “Four-Chain Collaboration” model is a closed-loop system from top-level design to teaching implementation and quality improvement: the Goal Chain as the driver, the Curriculum Chain as the carrier, the Practice Chain as the lever, and the Assessment Chain as the safeguard[3].

First, at the Goal Chain level, program objectives are translated into quantifiable graduation requirement indicator points with tiered attainment descriptors to ensure each competency is observable and measurable in instruction. By establishing a mapping among “graduation requirements—curriculum clusters—key assignments—rubrics—thresholds,” evidence sources and weightings are clarified so that objectives move from conceptual statements to direct drivers of teaching and learning activities. Technical directors and project managers from enterprises co-create the indicator library to ensure academic rigor and job authenticity, avoiding a disconnect between “on-campus standards” and “workplace competencies.”

At the Curriculum Chain level, curriculum clusters and resource systems are restructured around competency indicators to integrate knowledge, tools, and contexts. The course sequence progresses along “engineering cognition—data and digital construction—process control—contract and risk—integrated capstone,” retaining foundational platform courses such as engineering graphics, engineering economics, engineering laws and ethics, and engineering data analysis, while emphasizing professional cores such as schedule and resource optimization, engineering cost and BIM-based quantity takeoff, contract management and claims, and project management informatics. Cross-cutting content—digital construction and BIM collaboration, green construction and carbon accounting, smart site and IoT applications—is integrated, with integrative course design and the capstone project forming the culmination of competencies. Supporting resources include case libraries and datasets, BIM models and plug-ins, templates and task banks, and stratified rubric libraries, all interfaced with the LMS to enable blended and project-based organization. Real enterprise projects are structurally transformed into course tasks, with industry mentors deeply involved in course design, instruction, and evaluation. A multi-tempo class pattern of “short lecture—demo—drill—debrief—pitch” is adopted to ensure “learning for use, competitions to promote learning, and assessment to drive improvement[4].”

As the key carrier of industry–education integration, the Practice Chain emphasizes tiering, authenticity, and sustainability. On campus, foundational training combines virtual simulation and hands-on stations to ensure proficiency with tools and methods. Off campus, joint practice bases and government–industry–academia–research platforms host enterprise project tasks, where student teams produce periodic deliverables on ongoing or exemplar projects. Capstone theses align with real enterprise problems under a dual-supervisor system to advance comprehensive research and development. The project pool sources from ongoing and completed enterprise projects, public-sector open data, and competition datasets, complemented by IP and data compliance protocols to form a governance process for project selection, task decomposition, process supervision, and final acceptance. A unified digital toolchain spans BIM platforms, schedule–resource optimization, cost measurement, contract claims, and project collaboration systems, ensuring students transfer from tool practice to task embedding and from local skills to holistic solutions. Practice pathways are also aligned with academic competitions and professional certifications, building a linkage among “project—credits—honors—certification.”[5]

The Assessment Chain is evidence-centered, supporting attainment calculations and continuous improvement. For each indicator point, key assignments are designed—such as implementation plans and BIM clash detection reports, cost quantity comparisons and cost optimization reports, contract risk matrices and claim justification reports, and integrated presentations and defenses—with clear dimensions, explicit levels, and reasonable weightings to ensure comparability and reliability. At the course level, attainment is aggregated via weighted key assignments; at the program level, horizontal and vertical aggregation is realized through mapping matrices with thresholds and early-warning mechanisms. Industry mentors, faculty, and student self/peer assessors jointly participate, producing a three-tier evidence chain of “course closing reports—annual program report—improvement checklist.” Low-attainment indicator points trigger targeted measures—content updates, method adjustments, task substitution, resource supplementation, and faculty training—with effects verified in the next teaching cycle to realize a genuine closed loop.

4 PRACTICE IMPLEMENTATION AND EFFECTIVENESS ANALYSIS: FROM ROLLOUT TO OPTIMIZATION

To verify the effectiveness of the “Four-Chain Collaboration” model, the program undertook a three-academic-year effort encompassing revision of the training scheme, restructuring of curriculum clusters, upgrading of the practice system, and operation of the evaluation closed loop. In governance, a “Program Construction and Industry–Education Integration Committee” was established, comprising school leaders, program heads, enterprise representatives, and quality experts, with working groups for curriculum cluster construction, practice and project management, and evaluation and data governance[6]. Responsibilities and information flows were clarified to ensure coherent decision-making and execution. Deep collaboration agreements were signed with regional leading and emerging tech enterprises to implement “co-building courses, co-building bases, co-developing faculty, co-evaluating outcomes, co-using data,” reinforced by two-way mobility mechanisms such as enterprise mentor appointments and performance review, faculty enterprise residencies, and enterprise engineers in residence on campus—thus consolidating the organizational foundation for collaborative education[7]. In resources and funding, first-class program funds and enterprise investments were leveraged to build a BIM collaborative training center, a contract and claims simulation system, and a smart-site integrative training platform, forming a composite supply of “on-campus platforms + off-campus bases + online resources.” Teaching data standards and security compliance rules were instituted to unify the collection of key assignment scores, rubric dimension ratings, enterprise evaluations, course surveys, and graduate tracking data, and attainment dashboards were developed to inform course- and program-level improvements.

During implementation, the program’s training scheme was rebuilt based on the indicator library, clarifying course prerequisites and shared resources, defining each course’s key assignments and evaluation responsibilities, and elevating project-based learning to a core organizational method. Curriculum cluster iterations focused on modules such as “Digital Construction and BIM Collaboration,” “Engineering Cost and BIM-based Quantity Takeoff,” and “Contract Management and Risk Control,” with systematic embedding of enterprise cases and datasets[8]. Classrooms employed a cadence of “short lecture + drill + debrief + pitch,” alongside flipped learning and peer assessment to enhance engagement and reflective depth[9]. The practice system set “monthly deliverables” around ongoing projects, covering model audits, quantity comparisons, schedule monitoring, and risk identification. Capstone projects addressed real enterprise problems under dual-supervisor guidance, with some outputs piloted by firms or translated into improvement proposals. In parallel, “enterprise–course bilateral workshops,” “rubric alignment bootcamps,” and “case development sprints” supported faculty growth in project-based pedagogy, rubric design, and data-informed teaching.

Effectiveness evaluation centered on student competencies, course quality, and collaboration participation, using longitudinal comparative analysis. Student learning outputs improved across five dimensions—engineering cognition, digital application, process control, contract risk, and collaborative communication—with notably higher rubric scores in digital construction applications and contract–risk identification; enterprise evaluations also reported higher recognition of teamwork and communication. In course quality, student satisfaction and study time increased, forming a “high-intensity–high-support” learning climate; faculty reported that case-driven and tiered-task strategies effectively boosted participation and deep processing, and rubric use consistency improved. For industry–education collaboration, the frequency of enterprise mentor involvement in teaching, project review, and process supervision steadily rose; enterprise suggestions for course content updates were incorporated in subsequent iterations; and the stability of the practice-base project pool and data availability improved. Longitudinal tracking indicated better employment quality within one year after graduation, with higher proportions entering whole-process consulting, BIM consulting, and technical management roles in construction firms, and employers broadly noting that graduates “ramp up quickly, are proficient with digital tools, and collaborate and communicate smoothly.”

At the same time, continuous improvements are needed. Differences in regional industrial structures and project types hinder one-size-fits-all cases and tasks; courses should adopt a “general competencies + configurable modules” structure for rapid adaptation. Some project data face compliance and confidentiality constraints; data de-identification, near-real datasets, and virtual simulation integration should be used to enhance usability. Performance assessments and multi-stakeholder participation increase workload and scoring variance; shared item banks and rubrics, centralized calibration, and AI-assisted quality control are needed to improve efficiency and consistency. Faculty capabilities in digital construction and data analysis vary; enterprise residency programs, cross-domain workshops, and a tiered TA system can help. Evidence governance requires further strengthening by embedding evidence collection standards into the teaching calendar and LMS workflows, with automated reminders and missing-item tracking to ensure accurate attainment aggregation. Overall, experience indicates that “evidence-driven improvement, project-driven capability, and collaboration-driven quality” is a feasible and scalable pathway.

5 CONCLUSION

Against the backdrop of national first-class program construction and emerging engineering initiatives, talent cultivation in engineering management must shift from “course patchwork” to “systems engineering.” The proposed “Four-Chain Collaboration” model uses the Goal Chain to pull the Curriculum Chain, carries authentic contexts through the Practice Chain, and safeguards evidence and improvement via the Assessment Chain, alleviating issues of weak measurability of goals, shallow industry–education collaboration, fragmented practice scenarios, and incomplete evaluation loops. Practice results show enhanced student competencies in digital construction, contract and risk

governance, process control, and collaborative communication; more robust curriculum cluster structures and industry–education mechanisms; and normalized quality assurance operations. Future work will deepen along the lines of upgrading project data and scenario libraries, applying AI and data analytics to teaching evaluation and project practice, and refining evidence governance and educational research design, thereby improving sustainability, transferability, and replicability.

COMPETING INTERESTS

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REFERENCES

- [1] Papuraj X, Izadyar N, Vrcelj Z. Integrating Building Information Modelling into construction project management education in Australia: A comprehensive review of industry needs and academic gaps. *Buildings*. 2025, 15(1): 130-130. DOI: 10.3390/BUILDINGS15010130.
- [2] Engineering - Engineering Education; New findings from University of Cordoba in the area of engineering education reported (self-perceived benefits of cooperative and project-based learning strategies in the acquisition of project management skills). *Journal of Engineering*. 2018, 74.
- [3] Yuchan C. The five-factor model for the education of postgraduate CPC members taking the application of project management method as a means. *Communication and Education Review*. 2020, 1(2). DOI: 10.37420/J.CER.2020.014.
- [4] Yasuo U, Takahiro Y, Yoshihiro K. W-01 PBL course for leaders of small group in a framework of co-operative education. *JSEE Annual Conference International Session Proceedings*. 2010: 16-19. DOI: 10.20549/jseecn.2010.0_16.
- [5] Hirose Y, Kato T. Technological cooperative education programs for postgraduates and undergraduates in colleges of the social science and the science and engineering. *Bulletin of the Japan Society of Internship*. 2017, 15: 17-22. DOI: 10.24497/jsiwil.15.0_17.
- [6] Guo H. Research on the optimization strategy of project management on Sino-foreign cooperative education in colleges. *Frontiers in Educational Research*. 2022, 5(13): DOI: 10.25236/FER.2022.051319.
- [7] Zhang Q. Based on the integration of production and education, the path of school-enterprise cooperative education for engineering management specialty. *Region - Educational Research and Reviews*. 2024, 6(7): DOI: 10.32629/RERR.V6I7.2297.
- [8] Wang Y, Liang D, Zhou J, et al. Exploring the construction path of a collaborative education model for course clusters in interdisciplinary programs integrating management and engineering. *Trends in Social Sciences and Humanities Research*. 2025, 3(4). DOI: 10.61784/TSSHR3163.
- [9] Tan C, Huet I. The design of an active learning strategy to promote collaborative and research-based learning in project management education. *International Journal of Innovation and Learning*. 2021, 30(1): 19-47. DOI: 10.1504/IJIL.2021.116566.