

Research on the Reform Path of New Engineering Education from the Perspective of Professional-Innovation Integration

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Abstract: Emerging engineering fields are changing the knowledge boundaries, work processes, and value expectations associated with engineering occupations. Conventional programs, however, often treat disciplinary instruction and innovation-entrepreneurship education as separate curricular domains. Professional courses emphasize established theories and technical procedures, while innovation courses are commonly delivered as general electives, competitions, or short-term training detached from engineering problems. This separation limits students' ability to define open-ended problems, combine knowledge across fields, test technical ideas under operational constraints, and convert prototypes into solutions with social and economic value. Professional-innovation integration offers a reform perspective in which innovation is embedded in the formation of engineering competence rather than added after professional learning. Using literature analysis, comparative analysis, and inductive reasoning, this paper clarifies the connotation and operating logic of professional-innovation integration, compares conventional and integrated education models, examines three reform modes, and identifies recurrent institutional constraints. The analysis shows that effective reform depends on coordinated changes in curriculum architecture, practice settings, faculty work, evaluation, and organizational support. A systematic path is therefore proposed: reconstruct competency-based curricula around authentic engineering tasks; establish a progressive practical teaching ecosystem linking laboratories, projects, competitions, and enterprise settings; develop cross-boundary faculty teams with joint teaching and technical service responsibilities; redesign assessment around evidence of engineering judgment and innovation processes; and create stable governance and resource arrangements. The resulting framework places disciplinary depth, design capability, entrepreneurial judgment, professional ethics, and interdisciplinary collaboration within the same talent cultivation process. It provides an institutional reference for engineering colleges seeking to respond to artificial intelligence, intelligent manufacturing, green technology, and other emerging technological demands without weakening the foundations of professional education.

Keywords: new engineering education; professional-innovation integration; competency-based curriculum; practical teaching ecosystem; faculty development; talent cultivation

1. Research Introduction

The reorganization of production around artificial intelligence, industrial software, advanced manufacturing, new energy, and data-intensive engineering has altered what graduates are expected to do in their first years of employment^[1]. Employers increasingly require engineers who can interpret uncertain requirements, work across hardware and software boundaries, evaluate technical and commercial constraints, and revise solutions through evidence from use^[2]. Many engineering programs have responded by adding innovation modules, entrepreneurship lectures, maker activities, or competitions. Yet additions at the curricular margin rarely change the internal logic of professional education^[3]. Students

may learn design thinking in one course and complete tightly prescribed experiments in another, with little opportunity to transfer methods between them. Professional teachers may regard entrepreneurship education as outside disciplinary instruction, while innovation mentors may lack sufficient knowledge of engineering standards, safety, and production processes. The result is parallel provision rather than integration. New engineering education requires a more direct connection between professional competence and innovation practice. From this perspective, professional-innovation integration concerns the coordinated redesign of learning outcomes, course content, teaching tasks, practice environments, faculty responsibilities, and assessment evidence. Its purpose is not to turn every student into a business founder. It is to help engineering students recognize worthwhile problems, generate technically defensible alternatives, consider users and implementation conditions, and carry an idea through verification, iteration, and responsible application.

Existing discussions provide useful accounts of innovation courses, entrepreneurship platforms, project-based learning, and university-enterprise cooperation, but they often address these measures independently. Less attention is given to the institutional mechanisms that connect professional course sequences with innovation tasks across the full period of study. This paper treats integration as a program-level reform problem. It distinguishes integration from simple course addition, identifies differences among prevailing implementation modes, and explains why fragmented governance, weak faculty coordination, and output-oriented evaluation reduce reform effects. The proposed framework is intended for application in engineering programs with different disciplinary bases and industry connections.

The study uses literature analysis to define the reform domain, comparative analysis to distinguish education models, and inductive reasoning to derive common constraints and corresponding actions. The argument follows the sequence of concept definition, model comparison, problem diagnosis, path construction, and prospective judgment.

2. Core Connotation Reform Logic and Research Status Quo

2.1 Core Concepts and Reform Characteristics

New engineering education refers to the renewal of engineering talent cultivation in response to technological convergence, industrial restructuring, and changes in the public responsibilities of engineering^[4]. It includes the development of emerging specialties, the upgrading of established specialties, and the reorganization of learning around complex engineering practice. Professional education provides the disciplinary concepts, technical methods, standards, and occupational norms required for engineering work. Innovation-entrepreneurship education develops opportunity recognition, creative problem solving, resource coordination, value assessment, and implementation awareness. Professional-innovation integration is the deliberate coupling of these two domains through shared outcomes, common tasks, coordinated teaching, and connected assessment^[5]. Its unit of reform is therefore the talent cultivation system rather than an isolated innovation course or extracurricular activity.

An integrated model has four characteristics. Disciplinary knowledge remains the basis of credible innovation, so novelty cannot substitute for technical validity. Innovation processes are embedded progressively across foundational, core, and capstone courses instead of being concentrated near graduation. Learning tasks are drawn from real engineering contexts and retain constraints related to cost, safety, standards, users, sustainability, and manufacturability. Evidence of learning extends beyond examination scores to include problem statements, design records, prototypes, test data, failure analysis, intellectual property judgments, and team decisions. These characteristics place the engineering mindset and value creation within the same sequence of educational experiences.

2.2 Reform Logic under Professional Innovation Integration

Professional learning and innovation learning form a reciprocal relationship. Professional knowledge gives students

the analytical tools required to distinguish feasible ideas from superficial novelty. Innovation tasks, in turn, expose gaps in students' knowledge and create reasons to integrate concepts that are usually taught separately. At the curriculum level, this relationship converts course objectives into a developmental chain from understanding principles to solving defined problems^[6], formulating open problems, validating solutions, and considering application. At the teaching level, it shifts some classroom time from content transmission to guided inquiry, design review, and evidence-based iteration. At the organizational level, it requires professional departments, innovation centers, laboratories, and enterprise partners to share projects, facilities, mentors, and assessment rules. The reform logic is cyclical: emerging industrial tasks inform competency standards; competency standards guide curriculum and project design; project evidence reveals weaknesses in teaching; and the revised teaching system supports more advanced technical creation. Integration becomes sustainable only when this cycle is included in routine program governance.

2.3 Review of Domestic and Foreign Research and Practice

International engineering education has developed several approaches relevant to professional-innovation integration. Outcome-based accreditation directs attention to demonstrable graduate capabilities and continuous improvement. Design-based curricula organize learning around conceiving, designing, implementing, and operating engineering systems. Project-based and problem-based learning place students in situations where technical decisions must be justified with incomplete information. University innovation hubs and cooperative education extend learning into multidisciplinary and industrial settings^[7]. These approaches differ in emphasis, but they share two features: innovation is connected to disciplinary work, and student performance is judged through artifacts and decisions produced during engineering activity. Their limitations are also instructive. Short projects can privilege presentation over analysis, interdisciplinary teams can obscure individual learning, and enterprise projects can become routine production tasks unless academic outcomes are explicitly protected.

Current reform practice in China commonly combines new engineering construction, innovation-entrepreneurship education^[8], industry-education collaboration, and discipline competitions. Universities have created innovation credits, project courses, maker spaces, industrial colleges, and jointly supervised capstone projects. Some programs map competition tasks to professional courses or introduce enterprise problems into teaching. Progress remains uneven because activities are frequently managed by different offices, credit recognition is inconsistent, and successful competition teams may benefit without changing the experience of most students. Research increasingly calls for curriculum-wide integration, cross-disciplinary faculty teams, and process evaluation, but practical accounts still concentrate on individual courses or exemplary projects. A transferable reform framework must explain how these elements operate together under ordinary teaching conditions.

3. Multidimensional Comparative Analysis of Professional Innovation Integration

To clarify the organizational implications of the reform, two comparisons are presented. The first distinguishes conventional engineering education from an integrated model across the main components of talent cultivation. The second compares three implementation modes according to their content, advantages, limitations, and institutional conditions. The tables are analytical types rather than rankings; a program may combine modes or move between them as its capacity develops.

3.1 Comparison between Conventional Engineering Education and the Professional Innovation Integrated Model

Conventional engineering programs are often organized around stable disciplinary knowledge and course-specific examinations. Innovation activities occur outside the main curriculum and reach students unevenly. The integrated model

retains systematic professional instruction but reorganizes its application through progressive, authentic, and assessable innovation tasks. Table 1 identifies the main differences between the two models.

Table 1 Comparison between Conventional Engineering Education and the Professional Innovation Integrated Model

Comparison Dimension	Conventional Engineering Education	Professional Innovation Integrated Model
Cultivation Logic	Organized around disciplinary content coverage and course completion; innovation is added through general courses or extracurricular activities.	Organized around the progressive formation of professional competence through problem discovery, design, verification, iteration, and value assessment.
Curriculum Structure	Professional courses, innovation courses, competitions, and internships are managed as separate components with limited outcome mapping.	Foundational, core, integrative, and capstone courses share a competency map and use connected innovation tasks of increasing complexity.
Learning Tasks	Experiments and assignments have predetermined procedures and expected answers; technical correctness is judged within a single course.	Authentic engineering tasks retain open choices and constraints related to standards, users, cost, safety, sustainability, and manufacturability.
Teaching Organization	Individual teachers deliver course content; collaboration with innovation staff and enterprise mentors occurs occasionally.	Cross-boundary teams jointly design projects, teach related content, review technical decisions, and calibrate assessment across courses and settings.
Practice Environment	Laboratories, maker spaces, competitions, and enterprise placements operate independently, with uneven student access.	Campus and industry settings form a progressive ecosystem supported by a governed project pool, shared records, access rules, and technical support.
Assessment Evidence	Written examinations and final products dominate; prizes, patents, and presentations serve as visible innovation indicators.	Individual and team evidence includes problem statements, design records, prototypes, test data, trade-off analysis, failure reflection, and technical defense.
Graduate Capability	Graduates reproduce	Graduates apply disciplinary

	established methods effectively but may have limited preparation for ambiguous and interdisciplinary engineering work.	knowledge to define problems, compare alternatives, validate solutions, coordinate resources, and judge implementation responsibly.
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3.2 Comparison of Mainstream Professional Innovation Integration Reform Modes

Differences in disciplinary history, faculty capacity, industry access, and institutional investment have produced three common reform modes: curriculum-embedded, project-platform, and ecosystem-oriented integration. Each can support improvement, but each also creates characteristic risks. Table 2 summarizes their operating features and suitable institutional conditions.

Table 2 Comparison of Mainstream Professional Innovation Integration Reform Modes

Reform Mode	Core Reform Content	Main Advantages	Main Limitations	Suitable Institutional Conditions
Curriculum Embedded Mode	Revises course outcomes, assignments, and assessment so innovation processes appear progressively within the professional curriculum.	Broad student coverage; protects disciplinary depth; can begin with existing courses and moderate investment.	May remain course-specific; depends heavily on teacher design capability; external authenticity can be limited.	Programs with stable curricula and faculty willingness to coordinate but limited external platforms or funding.
Project Platform Mode	Uses studios, competitions, enterprise projects, and interdisciplinary platforms to connect professional knowledge with design and application.	Provides authentic constraints, visible artifacts, interdisciplinary teamwork, and strong student motivation.	Participation may be selective; projects can become detached from course progression; mentoring demand is high.	Institutions with accessible laboratories, active project mentors, and sustained industry or research partnerships.
Ecosystem Oriented Mode	Coordinates curriculum, project platforms, faculty	Supports cumulative competence, broad	Requires cross-unit authority, stable	Institutions with mature program

	teams, assessment, enterprise collaboration, and governance within one program quality system.	participation, faculty renewal, resource sharing, and continuous program improvement.	funding, shared evaluation rules, and a longer implementation period.	governance, interdisciplinary resources, and long-term industry-academia collaboration.
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4. Practical Dilemmas and Causes of Professional Innovation Integration Reform

4.1 Fragmented Curriculum Structure and Weak Progression of Innovation Competence

Many programs retain a curriculum structure in which general innovation courses, professional courses, practical training, and extracurricular competitions are designed independently. Learning outcomes use different terminology and are rarely mapped across semesters. Introductory innovation courses may ask students to propose business ideas before they possess the technical knowledge needed to assess feasibility. Later professional courses return to closed exercises that leave little room for problem definition or alternative design. Capstone projects then expect integrated performance without having provided repeated preparation. Credit substitution for competitions can widen the gap because a small number of high-performing students receive intensive mentoring while the main cohort completes conventional tasks. This fragmentation originates partly in departmental ownership: academic offices manage curricula, innovation centers manage competitions, and enterprise cooperation offices manage external projects. Without a program-level competency map and a sequence of shared tasks, integration depends on individual teachers and cannot produce consistent learning progression.

4.2 Insufficient Faculty Boundary Crossing and Limited Engineering Innovation Experience

Faculty capability is a major constraint because integration requires more than familiarity with entrepreneurship terminology or digital teaching tools. Professional teachers may possess strong disciplinary knowledge but limited experience in product definition, interdisciplinary coordination, technology transfer, or early-stage market assessment. Innovation instructors may be skilled in business models and project coaching but unable to judge engineering assumptions or testing quality. Enterprise mentors contribute current practice, yet their participation is often episodic and their guidance may emphasize delivery schedules rather than student learning. Workload systems reinforce separation by allocating hours to individual courses while giving limited recognition to team teaching, project supervision, enterprise practice, or the maintenance of shared project resources. Faculty development is frequently delivered through short lectures without subsequent design work or observed teaching. The underlying issue is not an absolute lack of expertise but the absence of a stable mechanism through which different expertise can be combined around curriculum tasks.

4.3 Shallow Industry Academia Collaboration and Weak Conversion of Engineering Problems

Industry participation is often described as a source of authentic projects, but direct transfer of enterprise tasks into classrooms is rarely effective. Some problems are too confidential, technically narrow, urgent, or dependent on facilities unavailable to students. Others are simplified until only a demonstration remains. Cooperation agreements may specify internships and visits without defining who converts production problems into teachable assignments, provides data, reviews intermediate decisions, or owns resulting intellectual property. When enterprise mentors appear only at final presentations, students receive little feedback during problem formulation and testing. Colleges may also select projects

for visibility rather than curricular relevance, leaving foundational courses disconnected from industry needs. The cause lies in the lack of an educational translation process. Authenticity should be preserved through constraints, data, standards, and stakeholder requirements, while scope and risk must be adjusted to students' developmental level. This requires joint project governance rather than occasional resource provision.

4.4 Single Outcome Evaluation and Misaligned Incentive Mechanisms

Evaluation systems frequently reward visible endpoints such as competition prizes, patents, registered companies, or polished prototypes. These indicators are easy to count but provide weak evidence of what most students learned. A patent may not demonstrate testing quality, and a competition result can reflect intensive coaching of a selected team. At course level, conventional examinations remain dominant because teachers lack common rubrics for assessing problem framing, engineering trade-offs, iteration, teamwork, and responsible decision making. Students therefore learn to optimize presentation and final appearance while concealing failed trials that could support deeper analysis. Faculty incentives create a similar distortion when awards are recognized but the slower work of curriculum redesign, interdisciplinary teaching, and project maintenance is not. The problem arises from a mismatch between reform objectives and accountability instruments. Integrated education needs process evidence and developmental benchmarks, not only final innovation outputs^[10].

4.5 Uneven Resource Access and the Absence of a Sustainable Practice Ecology

Professional-innovation integration depends on laboratories, software, data, materials, technical support, project time, and access to users or production settings. These resources are often distributed across departments with incompatible booking rules and separate budgets. Maker spaces may provide general fabrication equipment but lack the specialized instruments, safety procedures, and engineering supervision required for professional projects. High-cost platforms can remain underused when procurement is not accompanied by curriculum redesign and technician support. Students with prior competition experience may gain preferential access, while beginners encounter procedural barriers. External resources are also unstable when cooperation relies on a single enterprise contact or temporary funding. A sustainable ecology requires shared standards for access, maintenance, safety, project selection, and intellectual property. Without such rules, facilities become displays, projects terminate when funding ends, and integration remains an extracurricular privilege rather than a normal educational condition.

5. Systematic Reform Path of New Engineering Education through Professional Innovation Integration

5.1 Reconstruct Competency Based Curricula and Establish Progressive Learning Tasks

Curriculum reform should begin with a program-level competency framework that connects disciplinary knowledge, engineering practice, innovation processes, professional ethics, and collaboration. Graduate outcomes are decomposed into observable performances and then mapped across foundational, core, integrative, and capstone stages. Early courses can introduce problem observation, user needs, measurement, and simple redesign without demanding premature commercialization. Core courses should include open parameters, alternative technical routes, and explicit constraints so that students apply theory in decision making. Integrative courses can combine control, computing, materials, design, or management around system-level tasks. Capstone work should require requirements analysis, verification planning, cost and risk judgment, and communication with external reviewers. Each stage must produce assessable artifacts and prepare students for the next level. A curriculum committee should review duplication, missing prerequisites, and task difficulty annually using student work and industry feedback. This arrangement makes innovation competence cumulative and

keeps professional depth visible within interdisciplinary projects.

5.2 Build a Progressive Practical Teaching Ecosystem across Campus and Industry

Practical teaching should be organized as a connected ecosystem rather than a collection of laboratories, competitions, and internships. A four-level sequence can link verification experiments, course design projects, interdisciplinary system projects, and enterprise-connected capstones. Laboratories provide controlled conditions for learning methods; open project studios support iteration and fabrication; competitions supply time-bound performance tests; enterprise settings introduce standards, users, cost, and organizational coordination. Projects should enter a governed pool with information on learning outcomes, prerequisites, data availability, safety level, equipment needs, intellectual property, and expected duration. Teachers select and adapt tasks according to student level instead of importing them unchanged. Common digital records can preserve design versions, test results, mentor comments, and failure analyses across settings. Access rules should protect broad student participation, while advanced teams receive additional technical support without displacing the core curriculum. The ecosystem becomes educationally coherent when every setting contributes distinct evidence to the same competency framework^[9].

5.3 Develop Cross Boundary Faculty Teams and Reform Faculty Work Arrangements

Faculty development should be tied to actual curriculum production. Programs can form stable teaching groups that include disciplinary teachers, innovation-entrepreneurship educators, laboratory engineers, and enterprise specialists. Each group assumes responsibility for a sequence of related tasks, including project sourcing, instructional design, technical review, assessment calibration, and annual revision. Professional teachers need structured enterprise practice focused on problem definition, system integration, testing, and technology management rather than observational visits. Innovation educators need sustained participation in engineering courses and design reviews. Enterprise mentors should receive concise preparation on learning outcomes, feedback methods, student safety, and assessment boundaries. Joint lesson design, peer observation, project retrospectives, and rubric calibration provide evidence of capability growth. Workload and promotion rules should recognize team teaching, project supervision, resource development, technical service converted into teaching, and documented curriculum improvement. Such arrangements make interdisciplinary synergy part of ordinary faculty work rather than an informal personal contribution.

5.4 Reconstruct Process Based Assessment and Improve Incentive Alignment

Assessment should determine whether students can make and justify engineering decisions throughout an innovation process. Programs can combine individual and team evidence across problem definition, knowledge application, design alternatives, prototyping, verification, economic and social judgment, ethical conduct, and reflective revision. Rubrics should describe levels of performance with discipline-specific examples and be calibrated by professional teachers, innovation educators, and external reviewers. Design notebooks, code repositories, test records, review minutes, and version histories make learning processes visible and reduce dependence on polished final demonstrations. Individual interviews or technical defenses can distinguish personal competence within team products. Evaluation results should be aggregated at course and program levels to identify weak curriculum links, but they should not be reduced to a single innovation score. Student incentives should value careful testing, responsible abandonment of infeasible ideas, and documented improvement as well as awards or commercialization. Faculty evaluation should likewise recognize verified learning gains, reusable project resources, collaborative teaching, and sustained enterprise contribution^[10].

5.5 Strengthen Governance and Resource Support for Sustainable Reform

A sustainable reform requires a governance structure with authority over curriculum, practice platforms, faculty coordination, and external cooperation. A program-level committee can include academic leaders, course representatives, innovation educators, laboratory personnel, students, alumni, and industry members. Its responsibilities should cover competency mapping, project approval, resource allocation, safety, intellectual property, data use, and annual review. Funding should support consumable materials, platform maintenance, technician time, mentor participation, and small exploratory projects, not only major equipment purchases. Shared scheduling and transparent access rules can reduce departmental barriers. Digital repositories should store validated project briefs, datasets, rubrics, exemplary artifacts, and revision records while protecting confidential information. Reform can be introduced in selected course sequences, evaluated through student work and participation patterns, and expanded after weaknesses are corrected. Stable policies, rather than isolated campaigns, allow professional-innovation integration to become part of the institution's quality assurance process.

6. Conclusion and Prospect

6.1 Research Conclusion

Professional-innovation integration provides a program-level approach to new engineering education reform. Its central proposition is that innovation capability develops through the disciplined use of professional knowledge in open, constrained, and iterative engineering work. The comparison in this paper shows that adding general entrepreneurship courses or supporting a limited number of competition teams does not by itself change talent cultivation. Effective integration requires alignment among learning outcomes, curriculum progression, project settings, faculty collaboration, assessment evidence, and institutional resources. Current difficulties arise from fragmented ownership, discontinuous learning tasks, separated faculty expertise, weak educational translation of enterprise problems, output-centered evaluation, and unequal access to practice resources. The proposed path addresses these conditions through competency-based curriculum reconstruction, a progressive practical teaching ecosystem, cross-boundary faculty teams, process-based assessment, and stable governance. The framework preserves disciplinary rigor while extending students' capacity to formulate problems, compare alternatives, test claims, coordinate across fields, and consider implementation value. Its application should be adjusted to program maturity, industry access, and student characteristics, with improvement based on evidence from ordinary cohorts rather than exceptional project teams.

6.2 Development Prospect

Future professional-innovation integration will be shaped by the same technologies that are changing engineering work. Generative artificial intelligence, simulation, digital twins, cloud laboratories, and shared engineering data can shorten design cycles and expand access to complex tasks. Their educational value will depend on assessment practices that require students to verify generated outputs, explain assumptions, protect data, and retain responsibility for decisions^[11]. Interdisciplinary projects are also likely to involve a wider range of concerns, including carbon constraints, accessibility, cybersecurity, public safety, and technology ethics. Programs will need project governance capable of representing these requirements without diluting technical depth. Microcredentials and flexible modules may support personalized development, but they should remain connected to coherent program outcomes. Closer cooperation among universities, colleges, enterprises, research institutes, and local innovation organizations can enlarge the project pool and support faculty renewal. At the same time, research on reform should move beyond descriptive cases. Longitudinal evidence is needed on competency development, participation equity, transfer across courses, faculty workload, and

graduate performance. Such evidence can clarify which combinations of curriculum, practice, and governance produce durable improvements under different institutional conditions.

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