

Coupling Pathways for Building “Golden Majors” in Emerging Engineering at Higher Vocational Colleges under New Quality Productive Forces: A Regional Industry–Education Integration Community Framework

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Abstract: *Against the background of China’s transition from factor- and investment-driven growth to innovation-led high-quality development, new quality productive forces are reshaping industrial technologies, production organization, occupational structures, and regional skill demand. Higher vocational colleges are therefore required not merely to add several digital courses to existing engineering programs, but to reconstruct the logic of major development, curriculum organization, teaching resources, faculty capability, and technical services. This paper focuses on the construction of “golden majors” in emerging engineering and examines how regional industry–education integration communities can function as the meso-level institutional carrier that couples industrial transformation with professional education reform. Using policy-text analysis, literature synthesis, and system-coupling reasoning, the study integrates the perspectives of the Triple Helix, regional innovation systems, dynamic capabilities, absorptive capacity, and situated learning. It defines a vocational emerging-engineering golden major as a high-level major that demonstrates strategic alignment with regional industrial upgrading, advanced and transferable technical competence, deep integration of real production and learning, strong faculty and platform support, measurable innovation services, and sustainable multi-actor governance. On this basis, the paper constructs a six-dimensional coupling mechanism involving demand, knowledge, organization, resources, innovation, and quality feedback. It further identifies prominent constraints, including delayed major adjustment, fragmented curricula, shallow enterprise participation, weak conversion of enterprise technology into teaching resources, insufficient industry experience among teachers, platform idling, and evaluation systems that emphasize inputs rather than contributions. To address these problems, a coordinated pathway is proposed: establish a regional skills observatory; implement dynamic major governance; reconstruct competency standards and modular curricula around work processes; develop project-based teaching from authentic production tasks; create entity-based community governance and benefit-sharing rules; build mixed school–enterprise teaching teams; operate shared training and innovation platforms; embed technical services into talent cultivation; and establish evidence-based quality assurance. Finally, the paper presents a four-stage implementation roadmap and a multi-dimensional evaluation framework. The study argues that the decisive criterion of a golden major is not resource accumulation itself, but its sustained capacity to translate regional industrial change into high-quality technical-skill formation and to convert educational advantages into industrial innovation and inclusive regional development.*

Key words: *new quality productive forces, higher vocational education, emerging engineering, golden major, regional industry–education integration community, coupling pathway*

1 Introduction

1.1 Background and problem statement

The concept of new quality productive forces marks a shift in the logic of economic growth from extensive expansion toward productivity growth generated by revolutionary technological breakthroughs, innovative allocation of production

factors, and deep industrial transformation [1]. Its practical manifestations include the accelerated convergence of artificial intelligence, industrial internet, advanced manufacturing, new energy, new materials, biotechnology, and green technologies; the data-driven reorganization of production processes; and the emergence of new occupations that combine engineering operation, digital analysis, process improvement, quality control, and cross-functional collaboration. These changes do not simply increase the quantity of skilled workers required by industry. More importantly, they alter the knowledge structure, learning speed, work boundaries, and innovation responsibilities of technical personnel.

For higher vocational colleges, this transformation creates a structural challenge. Traditional engineering majors were often organized according to relatively stable occupational categories, equipment systems, and disciplinary knowledge. Their curriculum renewal cycles were longer than the technological iteration cycles of leading enterprises, and the connection between courses, work processes, and industrial standards was frequently indirect. Under new quality productive forces, however, regional industries increasingly require technicians who can operate intelligent equipment, understand data flows, diagnose complex faults, participate in process optimization, communicate across engineering domains, and learn continuously in rapidly changing workplaces. A major that remains tied to isolated subjects, outdated equipment, or a narrow job description may produce graduates who can complete routine operations but lack the integrated competence to support digital, intelligent, and green transformation.

China's recent vocational education policies have strengthened the institutional basis for responding to this challenge. The revised Vocational Education Law confirms vocational education as an education type with equal importance to general education and emphasizes industry–education integration, school–enterprise cooperation, practice orientation, and capability development [3]. The reform of the modern vocational education system further calls for extending the education chain, serving the industrial chain, supporting the supply chain, building the talent chain, and enhancing the value chain [4]. The first and second rounds of the high-level higher vocational school and major construction plan have shifted attention from favorable internal conditions toward service capacity, support capacity, supply–demand alignment, and high-quality industry–education integration [8–10]. The 2026 policy on reforming key teaching elements explicitly requires linked reform of majors, curricula, teaching materials, teachers, and internship and training, while encouraging enterprises to open technical standards, production resources, and occupational scenarios for educational transformation [11].

Within this policy and industrial context, the regional industry–education integration community has become a crucial organizational form. Municipal industry–education consortia and cross-regional industry communities are expected to gather government agencies, industrial parks, leading enterprises, vocational colleges, applied universities, research institutes, industry associations, and service organizations [5–7]. Their value lies not in the number of signed agreements but in their capacity to make information, standards, projects, equipment, teachers, sites, and innovation tasks flow across institutional boundaries. For an emerging-engineering major, the community can connect the regional industrial system with the educational system and can therefore provide a meso-level mechanism for converting industrial change into professional reform.

The central problem addressed in this paper is thus not whether higher vocational colleges should cooperate with enterprises, but how such cooperation can become a stable coupling mechanism for building high-quality emerging-engineering majors. The term “golden major” is used here as an analytical and developmental concept rather than a single official designation. It refers to a major that has high strategic relevance, strong technical and educational quality, distinctive regional contribution, and sustainable capacity for renewal. The construction of such a major requires a systematic relationship among industrial demand, competency standards, curriculum content, teaching teams, training environments, applied research, and governance arrangements. Fragmented reform of any single element is insufficient.

1.2 Research questions and significance

This study addresses three questions. First, what new requirements do new quality productive forces impose on the positioning, content, and performance of higher vocational emerging-engineering majors? Second, through which mechanisms can a regional industry–education integration community couple industrial upgrading with major construction? Third, what implementation pathways, governance arrangements, and evaluation indicators can make this coupling stable, reciprocal, and sustainable?

The theoretical significance of the study is to connect three bodies of discussion that are often treated separately: new quality productive forces as a macro-level driver, golden-major construction as a micro-level educational reform, and

regional industry–education integration communities as a meso-level collaborative institution. The study also extends the application of regional innovation system theory by treating higher vocational colleges not only as training providers but as institutions that support technology diffusion, process improvement, and the formation of skilled human capital in regional production networks.

Its practical significance lies in providing an operational framework for colleges and community partners. The framework is intended to help decision makers move from static major planning to dynamic demand sensing, from course addition to curriculum reconstruction, from symbolic cooperation to entity-based governance, from separate school and enterprise resources to shared platforms, and from input-centered evaluation to contribution-centered evaluation. It is especially relevant to regions where advanced manufacturing, digital industries, green energy, intelligent construction, modern transportation, industrial robotics, or other technology-intensive sectors are developing rapidly but where enterprises face shortages of technicians able to integrate operation, maintenance, data, and innovation tasks.

1.3 Literature review and research gap

Existing studies provide important foundations but leave several gaps. Research on new quality productive forces emphasizes technological innovation, factor reconfiguration, industrial upgrading, and high-quality development. Educational discussions have accordingly called for stronger support from education, science, and talent systems. Yet many analyses remain at the level of broad policy interpretation and do not explain how the new productive-force logic should be translated into concrete mechanisms for major governance, curriculum design, faculty development, and quality assurance.

Research on emerging engineering originated in the response of engineering education to a new round of scientific and technological revolution and industrial transformation [12]. It stresses interdisciplinarity, innovation, openness, and industry collaboration. International engineering education literature similarly highlights problem solving, design, teamwork, communication, decision making, initiative, and continuous learning as interdependent competencies rather than isolated outcomes [24–25]. Nevertheless, much of this scholarship focuses on undergraduate engineering education. Higher vocational education has a distinct type orientation: its learners must master complex technical action in real work settings, and its curriculum must connect occupational standards, production processes, equipment systems, and career development. A direct transplantation of university-level “new engineering” concepts may therefore neglect the practical, regional, and work-process characteristics of vocational education.

Studies of high-level majors and professional groups commonly examine alignment with industrial clusters, curriculum systems, teaching teams, training bases, and social services. They provide many useful construction elements, but the relationship among those elements is often presented as a checklist. The dynamic mechanism through which industrial change is sensed, interpreted, converted into educational standards, implemented in teaching, and evaluated through industrial feedback is less clearly specified. In particular, the word “golden” can easily become an input label attached to funding, equipment, awards, or demonstration projects rather than a description of sustained educational and industrial value creation.

Research on industry–education integration communities emphasizes multi-actor participation, resource sharing, joint training, standard development, and technology services. The Triple Helix literature explains that innovation is generated through evolving interactions among universities, industry, and government [13]. Regional innovation system research further demonstrates that vocational education institutions are essential to the diffusion and implementation of new manufacturing technologies, especially through the preparation of skilled workers and engineering technicians [15]. However, in practice, many communities remain alliance-like structures with weak operational entities, unclear rights and obligations, insufficient benefit sharing, and limited penetration into classroom teaching. The missing link is a mechanism-centered explanation of how community governance can drive the full-cycle construction of a major.

This paper addresses these gaps by constructing an integrated coupling framework. It treats the golden major as a dynamically renewed capability system, the regional community as a boundary-spanning platform, and new quality productive forces as the external driver that continuously changes the required configuration of knowledge, skills, technology, and organization.

2 Conceptual foundations and analytical framework

2.1 Educational implications of new quality productive forces

New quality productive forces can be understood through the coordinated upgrading of laborers, means of labor, objects of labor, and their combinations [1]. Translating this concept into vocational education produces four implications.

First, the competence structure of technical personnel must be upgraded. Skilled work increasingly combines hands-on operation with data interpretation, digital communication, system integration, environmental responsibility, and process innovation. Students need not become theoretical researchers in every emerging technology, but they must understand the operating logic, application boundaries, safety risks, and improvement potential of technologies used in their occupational field.

Second, learning content must be organized around technological systems and work processes rather than around isolated knowledge fragments. Intelligent manufacturing, for example, integrates mechanical systems, electrical control, sensors, industrial networks, software configuration, data acquisition, quality management, and maintenance. Curriculum design must therefore support the coordination of multiple competencies in authentic tasks, consistent with evidence that engineering practice depends on the integrated use of technical and professional competencies [24].

Third, educational resources must become more open and renewable. When enterprise standards, equipment, software, process documents, and real production problems are inaccessible to colleges, teaching content inevitably lags. The policy requirement that enterprises open and transform appropriate technical resources into educational resources provides an important institutional direction [11]. Such transformation must include confidentiality review, pedagogical redesign, version management, and joint ownership arrangements.

Fourth, the performance of a major must include contribution to industrial upgrading. A vocational emerging-engineering major should not be evaluated solely by enrollment, graduation, facilities, or competition awards. It should also demonstrate graduate adaptability, enterprise satisfaction, technical service outcomes, improvement of production practices, support for small and medium-sized enterprises, and capacity to promote inclusive regional development. These indicators reflect the broader goal of a vocational education system aligned with regional development and industrial layout [2].

2.2 Definition and characteristics of a vocational emerging-engineering “golden major”

A vocational emerging-engineering major is not simply a newly named major in an emerging industry. It may be a new program, an upgraded traditional program, or an interdisciplinary direction within a professional group. Its defining feature is that it is reconstructed around new technological paradigms, new production modes, and new competence combinations. For example, a traditional electromechanical major may evolve toward intelligent equipment operation and maintenance; an automotive major may be reorganized around electrification, connectivity, intelligent diagnostics, and energy management; and a construction major may integrate building information modeling, intelligent sensing, prefabrication, and low-carbon construction.

In this study, a golden major has six characteristics. Strategic alignment means that the major serves national strategy, regional industrial positioning, and the development of key industrial chains. Competency advancement means that its graduate outcomes integrate technical operation, problem solving, digital capability, collaboration, quality awareness, safety, ethics, and lifelong learning. Curriculum authenticity means that learning content is derived from occupational tasks, technical standards, production processes, and real projects. Resource excellence means that mixed teaching teams, equipment, digital platforms, internship sites, and teaching materials are sufficient and continuously renewed. Innovation contribution means that the major participates in applied research, technology transfer, employee training, and enterprise process improvement. Governance sustainability means that responsibilities, funding, data, intellectual property, risk, and evaluation are governed through stable school–enterprise–government arrangements.

These characteristics distinguish a golden major from a temporarily advantaged major. A major may possess excellent facilities yet remain disconnected from regional demand; it may have strong enrollment yet weak occupational relevance; it may win competitions without improving normal teaching; or it may rely on a few key individuals without an institutional renewal mechanism. Gold quality is therefore a property of the whole professional ecosystem and its dynamic capability, not of any single resource or indicator.

2.3 Regional industry–education integration community as a meso-level institution

The regional industry–education integration community is a collaborative institution embedded in a specific regional economy. Compared with a bilateral school–enterprise partnership, it includes a wider set of actors and can coordinate issues that exceed the capacity of a single organization. Government departments can provide planning, policy, public platforms, and coordination; industrial parks and associations can aggregate demand; leading enterprises can provide standards, advanced scenarios, and technology diffusion; small and medium-sized enterprises can provide diverse application problems; colleges can organize talent cultivation and technical services; universities and research institutes can provide higher-level knowledge and research support; and human-resource and technology-service agencies can support employment, certification, transfer, and evaluation.

Its essential function is boundary spanning. Industrial demand is usually expressed in the language of products, orders, processes, equipment, cost, quality, and delivery. Education is organized through objectives, curricula, courses, teaching materials, assessment, and credits. The community must translate between these institutional languages. It should convert industrial foresight into major planning, work tasks into competency standards, enterprise technology into teachable resources, production problems into learning projects, and learning outcomes into evidence valued by employers.

The community should also reduce transaction costs. Individual colleges may find it difficult to negotiate access to many enterprises, while individual enterprises may lack the time to participate repeatedly in separate curriculum meetings. A shared entity can organize demand surveys, standard development, teacher practice, equipment sharing, student internships, technical projects, and quality evaluation. The objective is not to eliminate organizational differences but to create a rule-based interface through which differentiated actors can collaborate efficiently.

2.4 Theoretical synthesis

Five theoretical perspectives support the coupling framework. The Triple Helix explains why government, industry, and educational institutions must interact in innovation systems and why their roles can partially overlap in collaborative projects [13]. A regional industry–education community extends this logic by including industry associations, research institutes, parks, and service organizations while retaining the central coordination among public governance, production, and knowledge institutions.

Regional innovation system theory emphasizes that innovation depends on localized networks, institutions, learning processes, and knowledge circulation. Vocational education institutions play a particularly important role in the adoption and implementation of technology because skilled workers and technicians connect new knowledge with production practice [15]. This perspective supports region-specific major construction rather than uniform national imitation.

Dynamic capability theory explains how organizations sense opportunities and threats, seize opportunities through resource configuration, and transform routines in response to environmental change [16]. Applied to a major, dynamic capability means sensing skill changes, selecting reform priorities, mobilizing partners, and continuously reconfiguring curricula, teams, and platforms. Absorptive capacity complements this view by highlighting the ability to recognize, assimilate, transform, and apply external knowledge [17]. The community raises the absorptive capacity of colleges by creating repeated contact with enterprises and raises that of enterprises by providing access to educational and research resources.

Situated learning and workplace learning theories emphasize that competence is formed through participation in authentic social and technical practices rather than through decontextualized transmission alone [19–21, 30]. Consequently, the coupling pathway must move authentic tasks, tools, standards, roles, and feedback into learning environments and must move students and teachers into meaningful workplace participation. Constructive alignment and outcome-based education further require alignment among graduate outcomes, learning activities, and assessment [22–23].

Together, these theories suggest an analytical chain: external technological and industrial change creates new regional competence demand; the community senses and interprets that change; multi-actor governance converts it into professional standards and resources; authentic learning and innovation projects develop student and teacher capability; industrial application tests the outcomes; and feedback triggers the next cycle of transformation.

2.5 Research design

The paper adopts a conceptual research design combining policy-text analysis, literature synthesis, and system-coupling reasoning. National policy documents on new quality productive forces, vocational education, new engineering, professional standards, high-level major construction, and industry–education communities were reviewed to identify institutional requirements [1–12]. International and comparative literature was used to derive theoretical mechanisms concerning collaboration, regional innovation, dynamic capability, engineering competence, and workplace learning [13–31].

Rather than assigning an unverified numerical coupling coefficient, the study identifies the subsystems, interfaces, flows, governance conditions, and feedback loops that determine coupling quality. The unit of analysis is the vocational emerging-engineering major embedded in a regional community. The main analytical dimensions are demand coupling, knowledge coupling, organizational coupling, resource coupling, innovation coupling, and quality-feedback coupling. These dimensions form the basis for the pathway and evaluation framework developed below.

3 Coupling logic between new quality productive forces, the community, and golden-major construction

3.1 Demand coupling: from industrial change to dynamic major positioning

Demand coupling concerns the translation of regional industrial transformation into major positioning and graduate outcomes. New quality productive forces emerge unevenly across regions. One region may prioritize intelligent equipment, another new energy, marine engineering, digital services, modern agriculture, or low-carbon construction. Therefore, major construction should begin with the regional industrial chain rather than with fashionable technology labels.

A high-quality demand-coupling mechanism has three levels. At the strategic level, regional development plans, industrial maps, technology roadmaps, and key enterprise investments are analyzed to identify long-term directions. At the occupational level, job families, work processes, task boundaries, and qualification structures are examined. At the competency level, specific requirements are formulated for knowledge, technical skills, digital tools, problem solving, safety, quality, communication, and professional ethics. The community is responsible for connecting these levels and preventing a direct, simplistic conversion of short-term recruitment demand into a curriculum.

Demand coupling must balance responsiveness and educational stability. A major cannot be redesigned whenever one enterprise changes a software version, yet it cannot wait several years to respond to a new production paradigm. The solution is a layered structure: stable foundational competencies, periodically updated professional core competencies, and rapidly replaceable technology modules. This structure allows the major to serve current positions while preserving students' capacity for career transfer and lifelong development.

3.2 Knowledge coupling: from enterprise technology to curriculum and teaching resources

Knowledge coupling is the process of transforming distributed industrial knowledge into teachable, learnable, and assessable educational content. Enterprise knowledge is often tacit, context-dependent, proprietary, and embedded in equipment, routines, and experienced workers. Simply inviting an enterprise expert to give a lecture does not complete the conversion.

The community should establish a joint process for knowledge extraction and pedagogical transformation. Typical work tasks are first selected according to representativeness, technical value, learning progression, safety, and feasibility. The task is then decomposed into operating conditions, required knowledge, technical actions, data, standards, risks, collaboration roles, and quality criteria. Confidential information is removed or simulated. The result is redesigned as a project, case, digital twin, training task, or integrated assessment. Version numbers and review cycles are assigned so that teaching resources can be updated when technologies change.

Knowledge coupling also requires bidirectional flow. Colleges should not remain passive recipients of enterprise knowledge. Teachers and students can contribute through process documentation, testing, data analysis, user training, equipment modification, and small-scale technical innovation. When knowledge flows in both directions, enterprises gain practical value and are more willing to invest in educational collaboration.

3.3 Organizational coupling: from loose alliance to entity-based co-governance

Organizational coupling determines whether collaboration survives beyond ceremonies and personal relationships. A loose alliance can facilitate communication, but golden-major construction requires recurring decisions about program adjustment, resource allocation, teacher participation, student placement, assessment, intellectual property, and project income. These decisions need formal structures.

An entity-based governance model should include a council for strategic decisions, a professional construction committee for standards and curriculum, an operations office for projects and data, and specialized working groups for faculty, platforms, internships, and technical services. Leading enterprises and colleges should share core responsibilities, while government agencies and industrial parks provide coordination and public support. Small and medium-sized enterprises should be represented through associations or rotating seats to prevent the community from serving only a few large firms.

Rules should specify decision rights, membership obligations, cost sharing, benefit distribution, confidentiality, safety, data use, conflict resolution, and exit mechanisms. The community does not need to become a separate legal person in every case, but its operation must be institutionalized through contracts, budgets, personnel assignments, and annual tasks. The quality of organizational coupling can be observed in whether partners jointly make decisions, contribute resources, implement projects, and accept common evaluation.

3.4 Resource coupling: from ownership-based use to shared capability platforms

Resources for emerging-engineering education are expensive, diverse, and rapidly depreciating in technical relevance. No single college can continuously purchase every advanced device, software system, data platform, and production line. Resource coupling shifts the focus from ownership to accessible capability.

A regional community can map available resources across colleges, enterprises, parks, and research institutions and create a shared platform catalog. Some resources can be physically shared; others can be accessed through scheduled enterprise practice, remote laboratories, industrial data sandboxes, digital twins, or mobile training units. The platform should integrate teaching, real production, employee training, technology testing, and public technical services so that utilization is high and maintenance has multiple funding sources.

Human resources are equally important. A mixed team should include full-time vocational teachers, enterprise engineers, skilled masters, applied researchers, curriculum specialists, and technical support staff. The key is not occasional participation but structured co-work: joint task analysis, co-development of resources, co-teaching, co-assessment, and co-supervision of projects. Repeated collaboration converts individual expertise into organizational capability.

3.5 Innovation coupling: from talent supply to co-creation of regional value

Innovation coupling connects major construction with the technological improvement of regional enterprises. Higher vocational colleges are generally strongest in application-oriented, process-oriented, and site-oriented innovation. Their contribution may include equipment maintenance optimization, tooling improvement, quality inspection, energy saving, digital transformation of small processes, employee upskilling, standard operating procedure development, and localization of technology applications.

These tasks should be integrated into teaching wherever appropriate. A real enterprise problem can generate a teacher technical-service project, a student capstone project, several course cases, and a new training module. Conversely, student learning outcomes can be tested through enterprise adoption or expert review. This integration creates a productive cycle in which technical service renews teaching content, teaching produces human resources for innovation, and enterprise feedback raises educational quality.

Innovation coupling also expands the role of the golden major in the regional innovation system. It helps small and medium-sized enterprises, which may lack dedicated research departments, absorb and implement new technologies. This role is especially important because the diffusion of technology depends not only on invention but on technicians capable of installation, adaptation, operation, maintenance, and continuous improvement [15, 17].

3.6 Quality-feedback coupling: from periodic inspection to continuous evidence loops

The final dimension is quality-feedback coupling. Traditional evaluation often occurs after a construction period and relies on documents, expenditures, facilities, and selected achievements. Such evaluation can verify compliance but may not reveal whether the major remains aligned with changing industrial practice.

A continuous feedback loop should collect evidence from students, graduates, teachers, enterprise mentors, employers, technical-service clients, and regional labor-market data. Graduate competence should be assessed through integrated tasks and workplace performance rather than through course scores alone. Enterprise feedback should distinguish immediate job readiness from longer-term development potential. Curriculum review should use evidence about which tasks graduates perform, where they encounter difficulty, and which new technologies or standards are emerging.

Feedback must lead to decisions. The community should hold periodic evidence-review meetings and publish an annual professional adaptability report. Courses, modules, equipment, teacher development, and partnership arrangements should be modified according to documented findings. Coupling is mature only when feedback changes the system rather than merely being archived.

4 Main constraints in current practice

4.1 Delayed and imprecise major adjustment

Some colleges adjust majors mainly through administrative cycles, enrollment pressure, or imitation of other institutions. Regional industrial analysis may remain at the level of broad sector names, without distinguishing industrial-chain links, enterprise types, technology maturity, or job families. As a result, a major can appear aligned with an emerging industry while its curriculum continues to prepare students for traditional tasks. Excessive pursuit of “new” names may also fragment enrollment and weaken foundational capacity.

4.2 Fragmented curriculum and weak integration of digital, green, and intelligent competence

Emerging technologies are often introduced as isolated elective courses. Artificial intelligence, industrial internet, digital twins, carbon management, or data analysis may be taught independently from core professional tasks. Students know concepts but cannot use them to diagnose equipment, optimize processes, control quality, or improve energy performance. The deeper problem is that the curriculum remains subject-centered rather than work-process- and system-centered.

4.3 Shallow enterprise participation and weak benefit mechanisms

Enterprise participation frequently concentrates on internships, donations, ceremonies, or occasional lectures. Curriculum decisions remain school-dominated, while enterprises see limited direct return from long-term educational investment. Without cost sharing, benefit distribution, project income rules, and recognition of personnel contributions, cooperation depends on goodwill and personal relationships. Small and medium-sized enterprises are particularly likely to be excluded because they lack dedicated liaison staff.

4.4 Insufficient conversion of technology into educational resources

Even when colleges cooperate with advanced enterprises, technology does not automatically enter the classroom. Confidentiality, safety, production pressure, complex equipment, and tacit knowledge create barriers. Teachers may receive a factory visit but not enough access to analyze tasks and develop teachable projects. Enterprise materials may be copied directly into teaching without pedagogical sequencing, or they may become obsolete because no version-management mechanism exists.

4.5 Faculty capability gaps

Many vocational teachers possess strong disciplinary knowledge and teaching experience but limited recent participation in advanced production, while enterprise experts may possess rich practice experience but lack curriculum and assessment capability. Teacher enterprise practice is sometimes short, observational, or disconnected from teaching reform. Mixed teams may exist on paper but lack stable workload, remuneration, and co-teaching arrangements.

4.6 Platform construction without sustainable operation

Training bases may emphasize equipment acquisition and visual demonstration. Utilization, maintenance, software renewal, consumables, safety, and technical staff receive less attention. Enterprise production sites may be difficult to access during peak periods, while campus equipment may differ from current industrial systems. Without an integrated operational model covering teaching, training, certification, and technical service, platforms can become underused and financially unsustainable.

4.7 Input-centered evaluation and weak feedback application

Evaluation systems often reward funding, equipment, projects, awards, and publications more readily than graduate capability, enterprise adoption, regional service, or continuous improvement. Data are stored in separate departments and are not linked to decisions. This can encourage short-term achievement packaging rather than long-term professional renewal and may obscure whether the major actually supports new quality productive forces.

5 Coupling pathways for golden-major construction

5.1 Establish a regional skills observatory and dynamic major governance mechanism

The first pathway is to institutionalize demand sensing. The community should establish a regional skills observatory jointly operated by colleges, industrial parks, associations, leading enterprises, and public employment or statistical agencies. Its task is to integrate industrial policy, investment projects, enterprise technology roadmaps, recruitment data, occupational standards, job advertisements, graduate employment, salary and retention information, and expert judgment.

The observatory should produce three outputs. A regional industry–major map identifies which majors support which industrial-chain links and whether there are gaps, overlaps, or weak links. A technology–occupation–competency map identifies how technologies change tasks and competence requirements. A three-list mechanism identifies majors or directions to be developed urgently, majors to be digitally or greenly upgraded, and majors requiring restriction, merger, or withdrawal. This approach is consistent with the policy direction of rapid professional response and dynamic adjustment [10–11].

At college level, major governance should move from a fixed approval mindset to portfolio management. The professional construction committee should review foundational modules every three to five years, core modules annually or biennially, and frontier micro-modules each semester when necessary. Decisions should consider not only current vacancies but also occupational sustainability, student development, regional inclusion, and the capacity of partner enterprises to support authentic learning. A major should be expanded only when there is a credible talent demand, sufficient teaching capability, and a stable partnership ecology.

5.2 Build an outcome framework based on compound technical competence

The second pathway is to define graduate outcomes that reflect the new division of technical labor. A competency framework should be developed through joint task analysis rather than copied from job descriptions. It may include six domains: professional ethics and safety; engineering fundamentals; technical operation and maintenance; digital and data capability; integrated problem solving and improvement; and communication, collaboration, and lifelong learning.

Each domain should be expressed through observable performance. For example, “digital capability” should not be limited to knowing software concepts; students should be able to acquire and clean production data, interpret dashboards, configure basic industrial communication, use digital models, and recognize cybersecurity and data-ethics risks within the boundary of their occupation. “Innovation” should not be defined only as patent output; students should be able to identify waste, analyze causes, generate feasible improvements, test solutions, and document results.

The outcome framework should distinguish entry-level competence from development potential. Employers may value immediate operation, but graduates also need transferable foundations to adapt to equipment upgrades and occupational change. Stable engineering principles, mathematics, communication, and learning capability must therefore be preserved while frontier technologies are introduced. Constructive alignment requires every outcome to be linked to courses, projects, assessment evidence, and responsible teachers [22–23].

5.3 Reconstruct a modular curriculum around industrial chains, work processes, and project matrices

Curriculum reconstruction should follow a “platform plus modules plus projects” architecture. The platform provides general education, professional ethics, engineering foundations, digital foundations, safety, quality, and green awareness. Professional core modules correspond to stable work-process segments such as system installation, commissioning, operation, diagnosis, maintenance, inspection, or process control. Flexible modules correspond to specific regional technologies, equipment brands, application scenarios, certificates, or enterprise needs. Integrated projects connect multiple modules and require students to complete authentic engineering tasks.

A project matrix should be built across semesters. Early projects may use simplified equipment and clearly structured tasks; intermediate projects integrate multiple systems and data; advanced projects introduce ambiguity, cross-role collaboration, cost and quality constraints, and real enterprise problems. Each project should specify the industrial source, learning outcomes, technical standards, deliverables, roles, assessment criteria, required equipment, safety controls, and evidence retained in the student portfolio.

The curriculum should also support stackable learning. Frontier modules can be offered as micro-credentials to students, enterprise employees, and graduates. This arrangement improves flexibility and creates a lifelong learning relationship between the major and regional industry. However, micro-credentials should remain integrated with the major’s competency framework rather than becoming a collection of disconnected certificates.

5.4 Convert authentic production tasks into teaching, learning, and assessment resources

The community should create a standardized resource-conversion workshop. Enterprise engineers, vocational teachers, curriculum specialists, and technical staff jointly select and transform tasks. A useful conversion protocol includes seven steps: identify a representative task; clarify industrial value and technical boundaries; analyze the work process and competence; remove confidential or unsafe elements; redesign the task for learning progression; develop assessment rubrics and supporting materials; and pilot, review, and version the resource.

Resources should include not only text-based cases but also equipment data, fault records, process parameters, drawings, standard operating procedures, simulation models, videos, quality reports, and decision scenarios. Digital twins and data sandboxes are valuable where real equipment is expensive, dangerous, or inaccessible, but they should be combined with physical operation whenever possible. Students must experience the material resistance, uncertainty, coordination, and responsibility of real technical work.

Assessment should emphasize performance evidence. Integrated rubrics can evaluate technical correctness, process compliance, safety, data use, troubleshooting logic, product or service quality, teamwork, communication, and reflective improvement. Enterprise mentors should participate in the design and moderation of key assessments. To preserve fairness, responsibilities and scoring standards must be clear, and enterprise judgments should be combined with educational evidence rather than treated as unquestionable.

5.5 Create entity-based community governance with cost sharing and benefit sharing

Deep coupling requires stable governance. The community council should approve strategy, annual plans, budgets, and major evaluation. The professional construction committee should include representatives from leading and small enterprises, colleges, universities, industry associations, and where appropriate professional certification bodies. An operations office should maintain the project portfolio, resource catalog, data system, meetings, contracts, and performance records.

Each member should have a contribution account recording funds, equipment access, expert time, data, sites, projects, internships, and employment opportunities. Benefits may include priority access to training, recruitment, technical services, platform use, joint branding, policy support, and project income. A transparent contribution–benefit mechanism reduces free riding and makes participation defensible within each organization.

Contracts should address intellectual property and confidentiality in differentiated ways. Teaching resources derived from enterprise projects may use joint ownership, licensed educational use, or anonymized public versions. Student participation in technical projects requires clear agreements on authorship, remuneration where applicable, safety, and data use. A dispute-resolution process should be established before conflicts arise.

Government should focus on enabling conditions rather than replacing enterprise and college responsibility. Public support is most effective when it funds shared infrastructure, common standards, services for small and medium-sized enterprises, teacher development, and performance-based projects that generate public regional value.

5.6 Develop mixed school–enterprise teaching teams through project-based professional learning

The “dual-qualified” teacher should be understood as a role capability supported by a team system, not merely as an individual certificate. A mixed team can distribute expertise: college teachers lead learning design and student development; enterprise engineers contribute current technology and project constraints; skilled masters demonstrate tacit operations and quality judgment; applied researchers support analysis and innovation; and technical staff ensure platform operation.

Teacher enterprise practice should be redesigned around deliverables. Before entering an enterprise, the teacher identifies a target technology, process, or course problem. During practice, the teacher participates in actual tasks under a mentor and collects evidence within confidentiality rules. After practice, the teacher must produce a transformed teaching project, updated module, technical report, or service outcome. The enterprise mentor evaluates work participation, and the college evaluates educational conversion. This process develops both industrial competence and absorptive capacity [17].

Enterprise experts also require pedagogical development. Short courses and co-teaching support should cover learning outcomes, student differences, safety, questioning, assessment, and feedback. Workload and remuneration should reflect preparation and assessment, not only classroom hours. Over time, stable co-teaching pairs and project teams should replace one-off guest lectures.

5.7 Operate shared training and innovation platforms as multi-functional capability centers

A shared platform should be designed from its service portfolio, not from an equipment list. Its functions may include student practical teaching, enterprise employee training, teacher practice, occupational certification, technology testing, equipment commissioning, process optimization, innovation competitions, public science education, and services for small and medium-sized enterprises.

The operating model should specify annual utilization targets, access rules, technical staffing, maintenance responsibility, software renewal, consumable costs, safety management, data governance, and income distribution. A platform manager with both technical and operational competence is essential. Equipment should be selected according to representative technical principles, interoperability, and teaching scalability, rather than the pursuit of the newest or most expensive brand.

A distributed platform model is often preferable. The college hosts foundational and repeatable training; leading enterprises provide advanced and real production scenarios; research institutions provide specialized testing; and digital platforms connect resources. Students progress from campus simulation to shared training and then to enterprise production. This progression reduces safety and production risks while maintaining authenticity.

5.8 Embed applied research and technical services into the talent-cultivation cycle

Technical service should be treated as a curriculum-renewal engine. The community can establish a problem bank in which enterprises submit needs related to equipment, quality, energy, digitalization, logistics, testing, or employee development. Problems are screened according to educational value, feasibility, confidentiality, and risk. They are then assigned to teacher–student teams or joint school–enterprise teams.

A project should generate multiple outputs: an enterprise solution, teacher capability, student evidence, a new case or module, and data for curriculum review. This “one project, multiple transformations” principle prevents research and teaching from becoming separate systems. It also makes enterprise participation more valuable, because cooperation produces visible operational improvement.

For small and medium-sized enterprises, the community can provide shared diagnostic services, technology clinics, and modular training. Such services strengthen regional diffusion of new technologies and help the golden major demonstrate public value beyond the employment of its own graduates. The college should nevertheless define

boundaries: projects must match its capability and educational mission, and commercial work should not displace student learning or create unmanaged legal and safety risks.

5.9 Establish digital, evidence-based quality assurance and continuous improvement

A professional quality dashboard should connect data across recruitment, learning, projects, internships, employment, enterprise feedback, faculty development, platform use, and technical services. The purpose is not surveillance or ranking for its own sake, but evidence-based diagnosis. Data definitions, access rights, privacy, and review procedures must be standardized.

The core of quality assurance is the outcome evidence chain. Each graduate outcome is mapped to courses and projects; each assessment generates retained evidence; samples are moderated by school and enterprise experts; results are analyzed by cohort and task; and improvement actions are assigned, funded, and followed up. Graduate and employer surveys should be supplemented by workplace performance evidence, professional certificates, project portfolios, and interviews.

An annual professional adaptability report should answer four questions: Is the major still aligned with the regional industrial chain? Are students achieving the intended compound competencies? Are community resources being converted into normal teaching? Is the major contributing to enterprise innovation and regional development? The report should lead to decisions on enrollment, modules, faculty, platforms, partnerships, and resource allocation. Public disclosure of selected indicators can improve accountability while confidential enterprise and student data remain protected.

6 Implementation roadmap and evaluation framework

6.1 Four-stage implementation roadmap

Implementation can proceed through four stages. The diagnostic stage, usually lasting six to twelve months, establishes the community governance structure, regional industry–major map, competency gap analysis, resource inventory, and baseline indicators. Its main deliverable is a jointly approved professional transformation plan rather than a list of construction purchases.

The co-design stage develops graduate outcomes, curriculum architecture, project matrices, resource-conversion protocols, faculty plans, platform operation rules, and evaluation standards. Pilot modules and projects should be selected where enterprise commitment and teacher readiness are strongest. Early success is important, but pilots should include ordinary students and routine teaching rather than only competition teams.

The pilot-and-validation stage implements the new curriculum in selected cohorts, conducts teacher enterprise practice, operates mixed teaching teams, and tests shared platforms and technical-service projects. Evidence is collected from student performance, enterprise review, safety, cost, platform utilization, and teacher workload. Problems are corrected before scaling.

The institutionalization-and-diffusion stage incorporates effective practices into formal talent-cultivation plans, workload systems, budgets, contracts, teacher evaluation, and community rules. Successful modules and standards can be shared with other colleges or enterprises in the region. The cycle then returns to demand sensing. A golden major is thus produced through repeated institutional learning, not completed once a construction period ends.

6.2 Responsibility configuration of major actors

The regional government or park authority should coordinate planning, public resources, policy alignment, and cross-department issues. It should avoid micromanaging curriculum while ensuring that public funds support shared and measurable regional value. Industry associations should aggregate demand, organize standards and expert participation, and represent small enterprises.

Leading enterprises should provide technology roadmaps, representative tasks, standards, mentors, sites, and evaluation, while benefiting from talent supply, training, and technical services. Small and medium-sized enterprises should provide diverse application scenarios and receive accessible services. Colleges remain responsible for educational quality, student development, curriculum integrity, and academic and ethical standards. Applied universities and research

institutes can support advanced technology, teacher development, and transfer. Students should be treated as participants with rights to safety, informed project participation, fair assessment, and recognition of their contributions.

Responsibility must be linked to resources and authority. An actor cannot be held accountable for an outcome without decision rights and support. Conversely, access to community benefits should be conditional on meaningful contribution.

6.3 Multi-dimensional evaluation framework

Evaluation should combine leading indicators, process indicators, and outcome indicators. Six dimensions are proposed.

Strategic alignment assesses the match between the major and regional industrial-chain priorities, the timeliness of major adjustment, and the stability of partner demand. Competency quality assesses integrated task performance, digital and green competence, professional ethics and safety, certification where relevant, graduate adaptability, and employer evaluation. Curriculum and teaching assesses the proportion and quality of authentic projects, alignment of outcomes and assessment, resource update cycles, and enterprise participation in normal teaching.

Faculty and platform capability assesses recent enterprise practice, mixed-team co-teaching, teacher technical-service outcomes, platform utilization, maintenance, and the accessibility of advanced scenarios. Innovation and regional service assesses enterprise problems solved, adoption of outcomes, employee training, support for small and medium-sized enterprises, standards or resources developed, and contribution to technology diffusion. Governance and sustainability assesses member contribution, joint decision making, cost and benefit mechanisms, data quality, safety, intellectual-property management, and completion of improvement actions.

No single indicator should determine quality. Employment rate alone may conceal low professional relevance; equipment value may conceal low use; enterprise income may conceal weak student learning; and awards may represent exceptional rather than normal performance. Evaluation should therefore use a balanced scorecard and should require narrative evidence explaining causal links and contextual differences. External peer review can improve credibility, but reviewers should include both vocational education and industry expertise.

6.4 Risk control

Four risks require particular attention. The first is technological fashion risk: majors may chase visible technologies without sufficient regional demand or foundational capacity. A portfolio review and pilot-before-scale rule can reduce this risk. The second is enterprise dominance risk: short-term production needs may narrow education and weaken transferable competence. Colleges must retain responsibility for comprehensive student development and ethical standards.

The third is data, safety, and intellectual-property risk. Students and teachers entering production sites or using industrial data require graded access, confidentiality training, cybersecurity controls, insurance, and safety responsibility. The fourth is inequality risk. If community resources are captured by a few institutions, enterprises, or high-performing students, regional and educational inclusion will be weakened. Shared-service rules, open application mechanisms, and support for small enterprises and ordinary learners are therefore essential.

7 Discussion

7.1 Theoretical contributions

The study makes three conceptual contributions. First, it positions the regional industry–education integration community as the meso-level mechanism that connects the macro driver of new quality productive forces with the micro reform of a vocational major. This avoids treating industrial change as an external slogan or treating major construction as an internally closed educational project.

Second, it reconceptualizes the golden major as a dynamic capability system. Its quality lies in sensing change, absorbing external knowledge, reconfiguring resources, implementing authentic learning, and generating regional value. This interpretation explains why a major with strong historical resources can decline if its renewal mechanism is weak, while a less advantaged major can improve through effective coupling and organizational learning.

Third, the framework expands regional innovation system analysis by emphasizing the educational conversion interface. Technology diffusion requires not only research organizations and firms but also institutions capable of transforming technology into skilled action. Higher vocational colleges, when deeply embedded in communities, can serve as talent hubs, application-innovation nodes, and knowledge translators.

7.2 Practical implications

For college leaders, the framework implies that professional reform should be governed as a cross-organizational portfolio rather than delegated entirely to an academic department. Investment should prioritize the mechanisms that renew content and capability: demand observatories, resource-conversion teams, mixed faculty, platform operations, and evidence systems.

For enterprises, participation should move from social support to strategic human-resource and innovation collaboration. Enterprises gain the most when they help define tasks, co-develop resources, mentor teachers and students, and use the community to solve shared technical and training problems. For government, the priority is to build public interfaces, incentives, and rules that lower collaboration costs and protect long-term educational value.

For teachers, the framework highlights a professional identity that integrates educator, engineer, curriculum designer, and applied innovator. For students, it promises learning that is more authentic and transferable, but it also requires stronger responsibility, teamwork, safety awareness, and self-directed learning.

7.3 Limitations and future research

This paper is conceptual and policy-oriented. It does not claim that the proposed mechanisms have identical effects across regions or industries. Regional industrial structure, governance capacity, college foundations, enterprise concentration, and labor-market conditions may significantly influence implementation. Future studies should conduct comparative case research across different types of regional communities, develop validated measurement instruments for the six coupling dimensions, and examine the relationships among coupling quality, student outcomes, enterprise innovation, and regional productivity.

Longitudinal research is particularly necessary because major construction and industrial transformation occur at different speeds. Future work should also investigate student experience, the participation of small and medium-sized enterprises, the cost effectiveness of shared platforms, and the ethical governance of industrial data and artificial intelligence in vocational learning.

8 Conclusions

8.1 Main conclusions

New quality productive forces require higher vocational engineering education to shift from incremental course updating toward systematic reconstruction. The central educational challenge is to translate rapid technological and industrial change into stable yet renewable competence formation. A regional industry–education integration community can perform this translation when it operates as an entity-based, rule-governed, and value-creating institution rather than as a loose alliance.

The paper identifies six interdependent coupling dimensions: demand, knowledge, organization, resources, innovation, and quality feedback. On this basis, it proposes pathways covering regional skills observation, dynamic major governance, compound competency standards, modular and project-based curriculum, enterprise-resource conversion, mixed faculty teams, shared capability platforms, applied technical services, and evidence-based quality assurance. These pathways form a closed cycle from industrial sensing to educational transformation, workplace validation, and continuous improvement.

The decisive standard of a vocational emerging-engineering golden major is not whether it possesses the most resources, but whether it can continuously convert regional industrial development into high-quality learning and convert educational capability into talent, technology application, and inclusive regional value. The coupling pathway is therefore both a professional construction strategy and a regional development mechanism.

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