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Graduation thesis of engineering and technology professional degree for building a strong education country"Quality-Capability" Double lift model: Research to help the international competitiveness of talents break through

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SUMMARY: *In the context of building a strong education country and global industrial reform, the graduation thesis of engineering and technology professional degree faces a "triple disconnect" between quality and ability, industry demand and international standards, which restricts the improvement of international competitiveness of talents.This study aims to explore the transmission mechanism of "thesis quality-core competence-international competitiveness", and construct a three-dimensional linkage model of "goal anchoring-path embedding-cooperative guarantee" for "quality and ability" double improvement by using literature research, questionnaire and enterprise interview.This model is oriented to international competitiveness, reconstructing the three-dimensional quality goal of "academic standard-practical innovation-international adaptation" and the four-dimensional ability goal system of "engineering practice", with supporting core modules such as dual-cabinet topic selection, three-module embedding, collaborative guidance and three-party evaluation.The practice of related majors in Tianjin Polytechnic University shows that the topic selection of the pilot group is 85.7% related to the needs of enterprises/international, the average score of core competence increases by 27.9%, and the application rate of international standards increases by 31.4%.The study proves that this model can effectively solve the traditional dilemma, and the three-way collaboration between "university, enterprise and international organization" is the key, which can provide a practical plan for the international competitiveness of engineering and technology professional degree talents.*

KEYWORDS: *Professional degree in engineering technology; Graduation Thesis; Quality and ability improvement; International competitiveness*

1 Introduction

1.1 Research background and significance

As the core support of national strategy, the implementation effect of education and power construction in the field of engineering technology is directly related to China's core position in the global industrial competition."China Education Modernization 2035" clearly states that "a large number of high-quality engineering and technical personnel with international competitiveness should be cultivated".As a key link between higher education and industry

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demand, the quality of postgraduate professional degree education, especially the quality of graduation thesis, has become an important measure to measure the core ability of engineering and technical personnel.The global industry is undergoing profound transformations centered on intelligent manufacturing, green energy, and digital technologies. The competition for international engineering professionals has shifted from "quantity" to "quality". While China maintains a significant advantage in the scale of its engineering talent pool, notable gaps persist in core competencies such as alignment with international standards, cross-cultural engineering collaboration, and cutting-edge technological innovation. This disparity becomes particularly evident in the final phase of professional degree education—theses ———where graduates face challenges in meeting global academic benchmarks.

Graduation theses for engineering technology master's programs are designed to fulfill dual missions of "cultivating practical skills" and "nurturing innovative thinking". However, they face three critical disconnects in practice: First, there is a disconnect between thesis quality and skill development. Most universities still prioritize academic rigor as the primary evaluation metric, overlooking how thesis writing actually drives core competencies like engineering practice and technological innovation [3]. Secondly, there exists a disconnect between academic research and industry demands, characterized by homogenized topic selection and excessive theoretical focus, with insufficient responses to corporate technical challenges and global industrial pain points [6]. Thirdly, the educational objectives remain misaligned with international competitiveness standards. Thesis designs fail to meet global accreditation frameworks such as ABET (American Council for Engineering Education Accreditation) and EUR-ACE (European Accreditation for Engineering Education), resulting in graduates lacking market adaptability in the global talent landscape.This disconnect not only weakens the practical value of professional degree education, but also restricts the breakthrough of international competitiveness of engineering and technical talents under the strategy of building a strong educational country.

Existing studies mostly focus on the optimization of graduation thesis quality or the ability cultivation of engineering and technical talents, and the research on the synergistic mechanism between them and the correlation with international competitiveness is scattered.By constructing the logical framework of "quality, ability and international competitiveness", this study clarifies the internal transmission mechanism among them, which can enrich the interdisciplinary theoretical system of professional degree education and talent competitiveness cultivation.In practice, the "quality-ability" dual improvement model proposed in this study takes the graduation thesis of engineering and technology professional degree as the core carrier, and provides an operational reform plan for universities through a systematic upgrading mechanism constructed by "goal coordination anchor, process deep embedding and subject multi-dimensional linkage";At the same time, it provides decision-making reference for enterprises to participate in talent training and the government to formulate professional degree education evaluation policies, and ultimately helps China's engineering and technical talents to realize the transformation from "local adaptation" to "international leading".

1.2 Literature review and research gaps

Through reviewing the research status at home and abroad, it can be seen that the international academic circle has formed mature experience in the construction of engineering technology professional degree graduation thesis:The United States mandates "practical problem-solving" as the core requirement for ME (Master of Engineering) thesis submissions, requiring papers to address real-world industry needs and pass expert reviews. In Germany's dual education system, engineering degree theses are jointly supervised by university advisors and industry mentors. These projects directly draw from frontline production processes and must demonstrate the application of international technical standards.These practices highlight the core logic of "ability embedding" and "industry collaboration", which provide important reference for China.Domestic research shows the characteristics of "two lines running parallel":Research on thesis quality primarily focuses on technical aspects such as refining evaluation systems and optimizing management processes, establishing a comprehensive quality control framework that covers the entire workflow from topic selection to writing and defense. Meanwhile, studies on talent development emphasize practical teaching reforms and the integration of innovation-entrepreneurship education, proposing project-based learning as an effective pathway for cultivating engineering competencies.However, existing research exhibits notable gaps: Firstly, there is a lack of systematic exploration into the synergistic mechanism between "paper quality" and "competency development", failing to position academic papers as the core vehicle for capability enhancement. Secondly, the study has not incorporated international competitiveness into its analytical framework, thus missing opportunities to establish alignment pathways between paper quality standards and global talent requirements – precisely the core breakthrough of this research.

1.3 Research ideas and methods

This study follows the logical main line of "problem diagnosis, model construction and practice verification": The research framework is first established through literature review that synthesizes core theories and domestic/international practices. Subsequently, diagnostic analysis is conducted via questionnaire surveys (encompassing postgraduate students in engineering disciplines at five national science and technology universities, faculty advisors, and technical experts from over ten enterprises) and in-depth interviews, which pinpoint current challenges in aligning thesis quality with competency requirements and bridging the gap with global competitiveness standards.On this basis, the "three-dimensional linkage" double improvement model is constructed; finally, the feasibility and effectiveness of the model are verified through the case analysis of two pilot majors.In terms of research methods, literature research method, questionnaire survey method and case analysis method are comprehensively used to ensure the scientificity and practical adaptability of research conclusions.

2 Core concepts and theoretical support

2.1 Core concept definition

2.1.1 "Quality" of a thesis for a professional degree

Different from academic dissertations, which take "theoretical depth and academic innovation" as the core orientation, the quality of professional degree dissertations should be based on the orientation of "practical and applied" talent training, and defined as a three-dimensional comprehensive value system of "academic norms, practical innovation and international adaptation".Among them, "academic norms" is the foundation, covering the rigor of topic argumentation, scientific research methods, standard writing format and compliance of academic ethics;"Practice innovation" is the core, requiring the paper to focus on real technical problems of enterprises, common problems of the industry or engineering application scenarios, and form implementable research results through technical improvement, solution optimization and process innovation;"International adaptation" is an extension, emphasizing that the paper should be in line with international standards such as ABET (American Association for Engineering Technology Accreditation) "outcome-based education" standard, EUR-ACE (European Engineering Education Accreditation System) "engineering competence framework", etc., and have international compatibility in research perspective, technical standards or achievement promotion.

2.1.2 "Quality and capability" dual improvement

Taking the professional degree thesis as the core link, we should build a synergistic mechanism of "quality standard guiding ability cultivation and ability growth feeding quality upgrading", rather than the simple superposition of the two.Its core connotation includes three aspects: first, goal coordination, the "three-dimensional requirements" of graduation thesis quality is bound with the "four dimensions" of engineering and technical talents' core ability (engineering practice, technological innovation, cross-cultural collaboration, project management), forming a corresponding relationship between "quality index and ability elements";The second is process embedding, which sets up ability training nodes in the whole process of paper selection, research, writing and review (such as enterprise research to exercise practical ability, international literature comparison and analysis to cultivate cross-cultural vision);The third is the closed effect loop. The quality evaluation of graduation thesis can reverse check the effectiveness of ability cultivation, and the achievements of ability improvement (such as patents and technical reports) can enrich the connotation of paper quality, so as to realize the synchronous advancement of the two.

2.1.3 International competitiveness of engineering and technical personnel

Based on the strategic demand for "international talents" in the construction of a strong education country, and combined with the competitive characteristics of the global engineering technology field, it is defined as "the comprehensive advantages of knowledge adaptability, competence and quality competitiveness of talents in international engineering scenarios".It can be decomposed into three core dimensions: first, standard adaptation ability, that is, to be familiar with and master international engineering technical standards, industry norms and certification requirements, and be able to meet the technical threshold of multinational projects;The second is cross-domain action ability, including cross-cultural communication and collaboration ability (such as international technical conference exchange, transnational team coordination), global resource integration ability (such as international technical literature utilization, overseas partner docking);Third, innovation leadership, that is, the ability to make technological innovation or solution optimization in cutting-edge engineering fields (such as intelligent manufacturing and new energy), and the ability to produce internationally recognized research results or practical performance.

2.2 Theoretical Foundation

2.2.1 Competency-based education theory (CBE)

Proposed by American scholars in the 1960s, the core logic of this theory is "taking ability cultivation as the core and job demand as the guide", which emphasizes that the educational process should design curriculum, teaching and evaluation links around the "ability goal".The support for this study manifests in two aspects: First, it provides methodological guidance for the "competency embedding" design of graduation theses——. Specifically, the "Four Core Competencies" of engineering professionals can be broken down into concrete elements (e.g., "engineering practice ability" can be subdivided into sub-elements like "on-site problem diagnosis", "technical solution design", and "equipment debugging operations"). These sub-elements are then integrated into key research phases of the thesis, such as requiring topic selection to address real-world issues and emphasizing mid-term evaluations to assess the rationality of solution designs.The second initiative establishes a competency-driven framework for evaluating graduation theses—— moving beyond traditional evaluation systems that prioritize form over substance. By prioritizing measurable competencies—including practical proficiency and the feasibility of innovative solutions—the framework positions thesis writing as a vehicle for skill development rather than an end goal, ensuring it serves as a pathway to cultivate professional capabilities.

2.2.2 Theory of synergy governance

Originating from the field of public administration, this theory takes "multiple subjects realize common goals through resource integration and power and responsibility coordination" as its core point, and its core elements include collaborative subjects, collaborative goals, collaborative mechanism and collaborative resources.In this study, the theory provides organizational logic support for implementing the "Quality-Competence" dual-enhancement model: On one hand, it clarifies the tripartite collaborative entities of "universities, enterprises, and international institutions" —— Universities are responsible for academic standards and theoretical guidance, enterprises provide practical scenarios and technical demands, while international institutions (such as international engineering accreditation organizations and overseas universities) offer international standards and exchange platforms;On the other hand, we should establish collaborative mechanisms—— through approaches like the "dual mentorship system" (university mentors + industry mentors), "international joint review" (domestic experts + global peers), and "resource-sharing agreements" (enterprises sharing equipment data, international organizations providing standard materials). These measures break down the limitations of single-source resources, creating a synergistic force that drives talent cultivation, quality enhancement, and competitive breakthroughs.For example, when enterprise technical experts participate in the topic selection and demonstration, the research direction can be ensured to meet the industry needs, thus improving the practical quality of the paper and students' engineering practice ability, which is exactly the concrete embodiment of the "resource complementarity and goal coordination" logic of collaborative governance theory.

3 The status quo and problems of "quality-ability" in professional degree graduation thesis and international competitiveness

3.1 Overview of current research status

In order to accurately grasp the reality of "quality-ability" coordination and international competitiveness alignment in master's dissertations in the field of engineering technology, this study adopts a mixed research method of "questionnaire + interview" to carry out empirical research.The study surveyed four representative master's engineering disciplines (Mechanical Engineering, Electrical Engineering, Computer Technology, and Software Engineering) across five universities (including three Double First-Class institutions and two provincial key universities). A total of 321 valid questionnaires were collected, comprising 258 from graduate students, 47 from academic supervisors, and 16 from administrative staff. Additionally, in-depth interviews were conducted with technical directors and HR managers from 13 enterprises spanning equipment manufacturing, new energy, and information technology sectors, accumulating 8.5 hours of interview duration.After statistical analysis of the survey data with SPSS26.0 and qualitative coding of interview text with Nvivo12, the following current situation and problem judgments were formed, and targeted improvement suggestions were put forward based on the survey conclusions.

3.2 Current situation feature analysis

3.2.1 Quality of graduation thesis: academic standards are up to standard but practical and international adaptability is insufficient

Survey findings indicate that the "basic quality" of master's theses in engineering disciplines has been effectively ensured: 82.3% of supervisors and 76.5% of administrators report significant improvements in academic standards over the past three years, including formatting compliance, reference completeness, and logical structure rationality. This progress is directly linked to universities' strengthened thesis management systems, such as proposal reviews, mid-term checks, and plagiarism detection. However, three critical gaps remain in core quality dimensions: First, weak industry relevance in topic selection—only 31.7% of graduate students cited "real enterprise technical needs" as their thesis topics, with the majority (45.2%) choosing "sub-directions of supervisors' projects" or "theoretical simulations." For instance, 38% of 2022-2024 mechanical engineering theses at a university focused purely on theoretical topics like "Finite Element Analysis of a Part" and "Algorithmic Simulation Optimization," lacking practical applications. Second, poor commercialization rate—only 9.8% achieved "small-scale enterprise adoption," while 82.5% remained unconverted. Third, insufficient international alignment: merely 5.7% of topics addressed "international engineering standard integration" (e.g., ISO/IEC applications), significantly below global averages for similar professional degree theses.

3.2.2 "Quality-ability" coordination: the disconnection between ability cultivation and paper quality is prominent

Research reveals that master's theses fail to fully leverage their "guiding role" in cultivating core competencies. Two critical issues emerge. First, the disconnect between thesis processes and practical skill development is evident: 67.2% of graduate students report their academic training aligns with academic research requirements, yet demonstrate limited improvement in engineering competencies (e.g., field debugging, technical implementation) and innovation capabilities (e.g., patent applications, process optimization). A corporate technical director observed during interviews: "Most professional degree theses exhibit excessive academic rigor. While some papers present technically feasible solutions, practical implementation issues expose gaps in real-world applicability." Second, competency deficiencies directly undermine thesis quality. 43.5% of supervisors note that students' lack of cross-cultural literature analysis skills prevents them from accurately grasping global research frontiers, resulting in repetitive innovation points. Meanwhile, 38.9% admit their inadequate project management skills lead to delayed progress and rushed finalization, compromising quality standards. This creates a vicious cycle: subpar quality → insufficient skill development → even greater difficulty in improving outcomes.

3.2.3 Connecting with international competitiveness: gaps in standards and evaluation

From the perspective of international competitiveness alignment, the current thesis system exhibits "three critical gaps": First, the gap in international standard alignment, where only 8.3% of universities require compliance with international engineering accreditation standards in their graduation requirements. Most institutions still rely solely on "domestic academic norms", resulting in graduates 'insufficient familiarity with international standards like ISO and ASTM (with only 21.4% of postgraduates indicating "some knowledge of international standards"). Second, the gap in participation in international evaluations, where 91.7% of thesis reviews depend on "in-house supervisors + domestic peers", with only one surveyed university attempting "international peer anonymous reviews", and most review comments not being incorporated into final grades. An international engineering accreditation expert noted: "As the core achievement of talent development, whether graduation theses align with international standards and gain global recognition directly impacts graduates' competitiveness in international employment."

3.3 Core issues crystallized

3.3.1 Quality evaluation "emphasizes form over effectiveness" and is out of line with the goal of ability cultivation

The current thesis evaluation system remains entrenched in an "academic-centric" mindset: Formal metrics like formatting standards and logical structure account for 45% of the evaluation criteria, while core indicators such as practical innovation and competency attainment receive only 25%. The assessment process is dominated by universities alone, with input from industry experts and international peers serving merely as references rather than mandatory requirements. This misguided approach drives professional degree students to focus on "pure academic pursuits" instead of developing essential skills like engineering practice and technological innovation through research. As a result, "thesis quality" and "competency development" operate as separate entities, failing to create synergistic improvements that would enhance both aspects.

3.3.2 The research process is "closed-door", which is out of line with international industrial needs and standards

On one hand, the topic selection process lacks an "international perspective + industry anchoring" approach, with underdeveloped collaborative mechanisms between universities, enterprises, and international organizations. This results in research papers failing to address global industrial pain points (such as international certification challenges for new energy equipment and cross-standard compatibility issues in smart manufacturing). On the other hand, the research process lacks international resource support. Universities provide very few resources like "international engineering standard databases" or "overseas practice bases" for graduate students, preventing them from accumulating experience in applying international standards and cross-cultural collaboration – critical competencies for global competitiveness. Consequently, academic achievements naturally struggle to meet the demands of international engineering scenarios.

3.3.3 The support system is "fighting alone", and the mechanism of multi-dimensional collaborative education is missing

The enhancement of "quality-capability-international competitiveness" requires collaborative efforts from universities, enterprises, and international organizations. However, the current support system exhibits a pronounced "fragmentation of stakeholders": At the university level, the mentorship team lacks dual-qualified faculty members, with only 17.8% possessing over three years of industry experience, making it challenging to effectively guide practice-oriented thesis research. At the enterprise level, merely 29.6% of surveyed companies have established "authentic" graduate training practice bases, while most enterprises either nominalize partnerships or refuse to share technical resources citing "commercial confidentiality" or "cost pressures". At the international level, only one surveyed university has established "joint thesis guidance" collaborations with overseas institutions, and these mostly remain superficial arrangements without forming standardized international standard sharing mechanisms or joint review systems. This fragmented approach results in graduation thesis quality improvement lacking practical scenario support, capability cultivation lacking diversified resource empowerment, and breakthroughs in international competitiveness lacking standardized channels and safeguards.

3.4 Targeted improvement suggestions

3.4.1 We will optimize the "quality-capability" dual-oriented evaluation system and solve the dilemma of "emphasizing form over effectiveness"

To address the disconnect between evaluation systems and competency development, a dual approach of "indicator restructuring" and "expansion of evaluators" is required. First, adjust indicator weights: Increase the weight of "practical innovation" (e.g., feasibility of outcome implementation, alignment with corporate needs) and "competency achievement" (e.g., demonstration of engineering practice and cross-cultural collaboration) to over 40%, while reducing formal indicators like "format compliance" to below 20%. Simultaneously, introduce an "international standard compatibility" indicator (e.g., quality of international literature citations and depth of international standard application). Second, establish a tripartite review mechanism involving university mentors, corporate technical experts, and international peers. Corporate experts focus on evaluating "practical value," while international peers emphasize "international competitiveness alignment." All three parties' evaluations will be incorporated into final scores (with weights allocated at 4:4:2), preventing orientation bias caused by single-source assessments.

3.4.2 Build a "school-enterprise-international" collaborative research support mechanism, break the "closed-door" barriers

To bridge the gap between research needs, industrial demands, and international standards, three key measures should be implemented: 1) Establish a collaborative topic selection database. Universities should partner with industry leaders and global engineering organizations to annually compile "global industry pain points" and "corporate technology requirements", requiring graduate students to select or develop research topics based on these lists, ensuring practical relevance and international alignment. 2) Build an international resource-sharing platform. Universities can collaborate with libraries and ISO/IEC-certified institutions to open databases of international standards and overseas engineering case studies, while organizing regular "international standard application workshops" to enhance graduate students' cross-cultural research capabilities. 3) Promote collaborative research processes. Graduate students must complete at least two on-site enterprise surveys (led by corporate mentors) and one international research progress report (with online exchanges with overseas experts) during their thesis phase, ensuring continuous alignment with real-world scenarios and global advancements.

4 The core design of the "quality-capability" dual improvement model

4.1 Modeling objectives and principles

4.1.1 Principle of international competitiveness orientation

Guided by the international demands for engineering professionals in building a strong education nation, we integrate "alignment with global engineering standards and adaptation to worldwide industrial needs" throughout the entire model design process. Whether in setting thesis quality objectives, prioritizing competency development, or selecting evaluation metrics, all efforts ultimately aim to enhance talents' capabilities in "international standard alignment, cross-cultural collaboration, and technological innovation output" —effectively avoiding the pitfalls of "closed-door" quality optimization and skill cultivation.

4.1.2 The principle of double financing and promotion

To bridge the disconnect between "quality enhancement" and "competency development", we must establish an intrinsic framework where these two elements synergize: Graduation thesis quality standards should guide core competency cultivation (e.g., practical innovation requirements driving engineering practice training), while competency growth in turn enhances thesis quality (e.g., cross-cultural collaboration skills boosting international adaptability). This creates a virtuous cycle of "meeting quality standards → mastering competencies → achieving competitive breakthroughs".

4.1.3 Principle of multiple harmonies

By integrating the resources and strengths of three core entities—universities, enterprises, and international institutions—we establish a collaborative framework. Universities leverage their academic rigor and theoretical expertise, businesses provide practical implementation scenarios and technical support, while international organizations (including engineering accreditation bodies and overseas universities) offer standard alignment and global perspectives. Through clearly defined responsibilities and resource-sharing mechanisms, this approach effectively avoids the limitations inherent in single-entity dominance.

4.1.4 Principle of operability

The design model balances systematic rigor with practical implementation, with each module featuring concrete execution pathways and operational tools. For instance, the topic selection phase provides a structured framework combining "a global industry pain point database" and "corporate needs inventory," while the evaluation process specifies "multi-stakeholder review weights and procedures." This ensures universities, enterprises, and other stakeholders can directly reference these guidelines, avoiding overly theoretical or abstract designs.

4.2 Core framework of the model

The "three-dimensional linkage" framework is proposed: Based on the above principles, the overall framework of "goal anchoring, path embedding and collaborative guarantee" is constructed, and each dimension supports each other and serves for the dual improvement of "quality and capability" and the goal of breaking through international competitiveness.

First Dimension: Goal Anchoring: Aligning with international standards, we establish the "Three-Dimensional Quality Goals" (academic rigor, practical innovation, and global adaptability) and "Four-Dimensional Competency Goals" (engineering practice, technological innovation, cross-cultural collaboration, and project management) for graduation theses. A clear correspondence is established between quality indicators and competency elements, such as aligning the "global adaptability" quality goal with the cultivation of cross-cultural collaboration skills.

The second dimension: Path embedding. Throughout the thesis development process—from topic selection to research, writing, and review—we integrate competency training modules and quality control checkpoints. For example, the topic selection phase incorporates "global demand alignment" exercises, while the research phase features "industry practice implementation" and "international trend analysis" modules. This ensures that progress aligns with both quality standards and skill enhancement objectives.

The third dimension: Collaborative Assurance. Establish a tripartite coordination mechanism involving universities, enterprises, and international institutions, with clearly defined responsibilities for each party in goal setting, implementation pathways, and evaluation feedback. Universities are responsible for developing academic standards and coordinating campus resources, enterprises provide practical scenarios and align with technical requirements, while international institutions interpret global standards and organize peer reviews. This creates a collaborative framework characterized by "joint goal-setting, co-management of processes, and shared outcome assessment".

4.3 Core module design

4.3.1 Reconstructing the "quality-capability" goal system based on international competitiveness

Reconstruct the quality objectives around "international competitiveness adaptation" and transform abstract requirements into measurable quantitative indicators (see Table 1):

Table 1: Quality objectives of graduation thesis

Quality target dimension	Core requirements	Quantitative indicators (example)	International standard alignment basis
academic norms	Scientific research methods, compliance with writing format and academic ethics	The citation rate of literature is more than 95%, the repetition rate is less than 20%, and the research method is double verified by supervisors and enterprise experts	EUR-ACE“Academic integrity requirements”
Practice innovation	Respond to the real needs of enterprises, and the results have the potential to be implemented	The selected topics account for more than 80% of the enterprise demand, more than 60% of the research results are certified by the enterprise feasibility, and more than 30% of the technical solutions/patent prototypes are formed	ABET“Practical problem solving ability standard”
International adaptation	The international engineering standards are connected and the results are internationally comparable	At least 15 international core literature references (accounting for more than 30% of the references), involving the application of at least one international standard (ISO/IEC/ASTM), and the research results can be formed into English abstract/brief	ABET“Global engineering vision requirements”

Corresponding to the quality objectives, the required abilities of international competitiveness of engineering and technical talents are decomposed into four concrete elements, and the training focus of each ability in the paper process is defined (see Table 2):

Table 2: Four key elements of cultivation

Core competency elements	Focus of training	Correlation with paper quality
Engineering practice ability	On-site problem diagnosis, technical solution implementation, equipment debugging operation	Support the quality goal of "practical innovation" and ensure that the paper results meet the practical operational needs of enterprises
Technological innovation capacity	Patent mining, process improvement, application of cutting-edge technology	Enhance the depth of the quality goal of "practical innovation" and avoid homogeneity of paper achievements
Cross-cultural collaboration skills	Precise reading of international literature, interpretation of international standards, English technical communication	To ensure the realization of the quality goal of "international adaptation" and enhance the international recognition of the results of the paper
Project management capacity	Research progress control, resource coordination, results sorting and presentation	Ensure that the paper is completed on time and with good quality to support the goals of "academic norms" and "practical innovation"

4.3.2 "Capacity embedded" graduation thesis training path design

(1) Topic selection: "dual library linkage" topic selection mechanism

Build an "international industrial pain point database" and an "enterprise technology demand database" to achieve the precise alignment of topics with international competitiveness needs.

Dual-Database Construction: Universities collaborate with industry associations (such as the China Mechanical Engineering Society) and international engineering consulting institutions (such as McKinsey Global Institute) to update the "International Industry Pain Points Database" quarterly; while partnering with cooperative enterprises to collect the "Corporate Technology Demand Database" monthly.

Topic Selection Process: Supervisors and graduate students must select research directions from the dual databases or propose topics independently based on institutional needs. A "Global Competitiveness Alignment Report" must be submitted, demonstrating how the topic aligns with international industry trends and corporate demands. The proposal must pass tripartite review by university supervisors, industry mentors, and international consultants (overseas experts) before the research proposal can be formally launched.

(2) Research section: "Three Module Embedding" training

In the research stage of the paper, three modules of "practical training, innovation cultivation and international docking" are embedded to realize the simultaneous promotion of ability cultivation and quality improvement.

Practical training module: Postgraduates need to actually enter the enterprise practice base to complete the practical part of the training plan, and complete the "enterprise field research report" (including problem diagnosis, data collection, preliminary scheme design), which will be scored by the enterprise tutor and included in the mid-term assessment of the thesis;

Innovation cultivation module: carry out "patent mining workshop" with university intellectual property centers to guide graduate students to extract innovation points from research and form patent application documents, which serve as an important support for the quality of "technological innovation" in papers;

International docking module: carry out at least two research exchanges with tutors or experts from overseas partner universities, report research progress and obtain international cutting-edge suggestions, and form an "international exchange record" as the basis for the quality of "international adaptation" of the paper.

(3) Writing section: "International orientation" content requirements

It is clear that the paper should include two types of international guidance content and strengthen the quality of "international adaptation".

International standard adaptation demonstration: If the research involves technical scheme or product design, it is necessary to demonstrate the compatibility of the scheme with relevant international standards (such as ISO9001 quality management standard, IEC61508 functional safety standard), analyze the compliance and improvement space;

International promotion potential assessment: Add the analysis of "international promotion potential of research results" in the conclusion section, and explain the application scenarios, adaptation conditions and transformation paths of the results in different countries/regions.

4.3.3 "Double mentor + international consultant" collaborative guidance mechanism

(1) Composition and division of responsibilities of the guidance team

Build a "1+1+N" guidance team (1 school mentor, 1 enterprise mentor and N international consultants, N≥1), and clarify the rights and responsibilities of each role.

University mentors: lead academic standard guidance, be responsible for the scientific research methods, logical integrity of the thesis, compliance with academic ethics, and assist in connecting international resources;

Enterprise mentor: lead the practical direction guidance, responsible for the matching degree between the topic and enterprise needs, the feasibility of the implementation of research results, and the technical support of the practical link;

International consultant: lead international vision guidance, responsible for interpreting international engineering standards, commenting on the international adaptability of research, providing international cutting-edge research suggestions, and can participate in guidance online.

(2) Step-by-step guidance process

The guidance process is divided into three stages, each focusing on a different focus to ensure precision.

Proposal stage: The three parties participate in the proposal demonstration, the school mentor reviews the research method, the enterprise mentor reviews the practical value of the topic, and the international consultant reviews the international competitiveness and adaptability of the topic, forming the "Proposal Demonstration Opinion Form";

Mid-term stage: The enterprise mentor leads the mid-term review, focusing on the evaluation of practical progress and the potential of achievement implementation; the university mentor evaluates the research progress and academic norms; the international consultant evaluates the international docking situation and puts forward cutting-edge optimization suggestions;

Final draft stage: the university tutor reviews the academic quality of the final paper, the enterprise tutor reviews the practical value of the results, and the international consultant reviews the international adaptation content (such as English abstract and demonstration of international standards), and jointly issues the "final draft review opinion".

4.3.4 "Quality-ability-competitiveness" linkage evaluation system

(1) Multiple evaluation subjects and weight allocation

Break the single evaluation system of universities, introduce the "university + enterprise + international peer" three-party evaluation body, and allocate the evaluation responsibility according to the weight of 4:4:2:

University evaluation (40%): the evaluation group composed of campus tutors and professors in related fields will focus on evaluating the academic norms of literature and the scientificity of research methods;

Enterprise evaluation (40%): the evaluation group composed of enterprise mentors and technical directors will focus on evaluating the practical innovation of the paper and the potential of the results;

International peer evaluation (20%): the review group is composed of overseas cooperative school tutors or international engineering certification experts, focusing on evaluating the international adaptability of the paper and the potential of international competitiveness of talents.

(2) Linked evaluation index system

The design includes a quantitative evaluation system with 3 first-level indicators and 9 second-level indicators to realize the linkage assessment of "quality, ability and competitiveness" (see Table 3):

Table 3: Linkage evaluation index system

Level 1 indicators (weight)	Secondary indicators (weight)	Focus of evaluation	Data source
Quality of thesis (40%)	Academic Norms (10%)	Citation, format, ethical compliance	University review team + CNKI report
	Practice innovation (20%)	Association degree of selected enterprises, implementation of achievements and innovation points	Enterprise review team + Enterprise Practice Report
	International adaptation (10%)	International literature citation, standard application, international promotion potential	International Review Group + International Exchange Records
Ability enhancement (40%)	Engineering practice ability (20%)	On-site problem solving, technical solution implementation	Enterprise review team + practice assessment record
	Innovation and collaboration (15%)	Patent mining, cross-cultural communication, international communication	Tripartite joint evaluation + patent documents
	Project management capacity (5%)	Research progress control, resource coordination	Campus mentor + mid-term check record
Competitiveness potential (20%)	International standard adaptation capacity (8%)	Ability to interpret and apply international standards	International review group + standard demonstration section
	Recognition of international achievements (7%)	International evaluation of English outputs (summaries/briefs)	International review team + feedback from overseas experts
	Industry adaptability (5%)	The matching degree of achievements with international industrial needs	Enterprise review team + industry trend report

5 Model practice verification —— Taking the master's degree of computer technology and software engineering in Tianjin Polytechnic University as an example

5.1 Case selection background

Tianjin Polytechnic University, as a key municipal university in Tianjin and a "Double First-Class" institution, has its Master's programs in Computer Technology and Software Engineering as core pilot directions for the "New Engineering" initiative. Building on the university's strengths in the interdisciplinary field of "Textile Informatization and Intelligent Equipment", it has developed distinctive training programs in "industrial software R&D, intelligent system integration, and data security protection". Currently, there are over 280 postgraduate students enrolled in the Computer Technology program and more than 160 in the Software Engineering program. The university collaborates with 52 enterprises (including Huawei Tianjin Research Institute, Beijing Xiaomi Mobile Software Co., Ltd., 360 Smart City Digital Security Research Institute, and other leading IT companies) and has established joint training partnerships in information technology with overseas universities such as Asia University in South Korea and the University of Alberta in Canada.

The selection of these two majors as practical case studies is based on three core considerations: First, their strong professional alignment. Computer technology and software engineering serve as the core vehicles for cultivating engineering talents in the digital economy era, with their international competitiveness directly impacting the implementation of the "digital technology autonomy and controllability" strategy in building a strong education nation. Second, their representative existing issues. Data from the 2021-2023 graduation papers reveals prominent common problems—— Only 12.6% of topics originate from real corporate needs; merely 7.8% of graduates enter multinational IT companies or participate in international projects, highlighting the industry-wide challenges of "quality-capability disconnect and insufficient international adaptability." Third, their solid practical foundation. The university has established collaborative platforms like the "Tian Gong Software Industry-Education Integration Innovation Consortium" and partnered with Korea's Asia University to co-found an "International Joint Research Center," providing hardware support and institutional foundations for collaborative education among universities, enterprises, and international organizations.

In September 2023, Tianjin Polytechnic University's Master's programs in Computer Technology and Software Engineering implemented a dual enhancement model combining quality improvement and competency development. The initiative selected 20 postgraduate students from the 2022 cohort of Computer Technology and 15 from Software Engineering (totaling 45 participants, representing 34% of their respective cohorts) as pilot subjects. The remaining 68 postgraduate students (47 from Computer Technology and 21 from Software Engineering) were trained using traditional methods as control groups. The implementation spanned the entire thesis process from September 2023 to June 2024.

5.2 Modeling practice process

5.2.1 Restructuring the goal system

Based on IEEE (Institute of Electrical and Electronics Engineers) software engineering certification standards, ACM (International Computer Association) "computer professional competence framework" and international demand of textile information industry, the dual objectives of "quality and ability" are reconstructed for the two majors:

Quality Objectives: Clearly define quantitative requirements —— Ensure alignment between research topics and corporate needs with ≥80% relevance to global industry pain points; Prioritize interdisciplinary research in fields like industrial software and data security, with ≥30% of projects in these areas; Deliverable outcomes must include demonstrable software prototypes/technical solutions, with ≥60% passing corporate feasibility certification; Incorporate at least one ISO/IEC international standard (e.g., ISO/IEC27001 Information Security Management Standard, ISO/IEC12207 Software Engineering Standard).

Competency Objectives: Decomposed into 4 core competencies with 15 specific indicators —— Engineering Practice Competency (industrial software module development, intelligent system field debugging, implementation of data security solutions), Technological Innovation Competency (algorithm optimization, patent mining, software architecture innovation), Cross-cultural Collaboration Competency (precise analysis of international technical literature, English technical documentation writing, interpretation of international standards), and Project Management Competency (agile development process control, R&D resource coordination, iterative optimization of outcomes).

Through the "mentor, enterprise expert and international consultant" tripartite symposium to interpret the connotation of the goal, the "Dual Goal System Operation Manual" was compiled to ensure that the pilot teachers and students and partners reached a consensus.

5.2.2 Implementation of training pathways

By integrating multiple industry-academia collaboration centers and university research institutes, we established an enterprise needs database. The repository contains 35 selected projects covering key areas such as "International Standard Adaptation for Textile Intelligent Manufacturing MES Systems", "Cross-border Industrial Data Flow Security Compliance Solutions (in compliance with GDPR and China's Data Security Law)", and "Domestic Industrial Software Compatibility Testing Technologies", including 12 interdisciplinary research topics.

Pilot graduate students select research topics from two databases and submit an "International Competitiveness Alignment Report", which must demonstrate the relevance of their chosen topics to IEEE standards and the demands of the textile informatization industry. The proposal can only be approved for initiation after passing tripartite review by university mentors, corporate technical experts, and international advisors. Among the final 35 pilot topics, 24 (68.6%) were enterprise demand-oriented, while 11 (31.4%) involved interdisciplinary fields.

5.2.3 "Three modules +IT characteristics" training implementation

Strictly embed the module of "practical training, innovation cultivation and international docking", and refine the requirements according to the characteristics of IT majors:

Practical Training Module: Organize pilot graduate students to participate in on-site R&D at enterprise co-laboratories for no less than 10 weeks. The Computer Technology program focuses on "Industrial Software Module Development and Debugging", while the Software Engineering program emphasizes "Intelligent System Prototype Construction". Participants must submit a "Field Research Report", which will be evaluated by corporate mentors based on technical feasibility and engineering adaptability (accounting for 40% of the mid-term assessment).

Innovation cultivation module: Joint with the Intellectual Property Center of the university, guide the pilot graduate students to extract innovation points from algorithm optimization and software architecture innovation, and form 6 invention patent application documents;

International communication module: conduct at least two online exchanges with their international mentors and submit the "International Communication Record".

Writing section: "International orientation +IT characteristics" content specification

The pilot paper is required to add two special chapters: "International Comparative Analysis of Similar IT Technologies/software" (focusing on core algorithms, compatibility, and compliance with international standards) and "International Promotion Potential Assessment of Software Achievements" (including English technical abstracts and analysis of overseas application scenarios). International mentors will review the standardization and international adaptability of English documents.

5.3 Analysis of practical effect

(1) The quality of graduation thesis: the three-dimensional objectives have been improved by leaps and bounds

Compared with the core quality indicators of the pilot group (35 people) and the control group (68 people) (Table 4), the pilot group has significant advantages:

The correlation degree between topic selection and enterprise/international demand reached 85.7%, nearly 52 percentage points higher than that of the control group (33.8%), and the proportion of cross-field topic selection was 34.3%(only 7.4% in the control group);

13 achievements were certified by enterprises (certification rate 37.1%), forming 21 demonstrable software prototypes and 6 invention patent applications, compared with 3, 32 and 1 in the control group respectively; 12 papers applied ISO/IEC international standards (only 2 in the control group);

Table 4: Comparison of thesis quality indicators between pilot group and control group

Quality indicators	Pilot groups(n=35)	control group(n=68)	Improvement margin
Enterprise selection/ International demand relevance	85.7%	33.8%	+51.9 percentage points
Percentage of cross-cutting topics	34.3%	7.4%	+26.9 percentage points
Certification rate of enterprise feasibility	37.1%	4.4%	+33.1 percentage points
Number of demo software prototypes	21 item (60%)	32 item(47.1%)	+12.9 percentage points
Number of international standard applications	12 article (34.3%)	2 article(2.9%)	+31.4 percentage points

The quality objective "Achieving enterprise feasibility certification for ≥60% of outcomes" was only met by 37.1% in actual implementation, falling short of the preset target. This was primarily constrained by two objective factors: the unique nature of IT achievement certification and practical cycle limitations. Firstly, enterprise feasibility certification for IT achievements (especially industrial software and data security solutions) requires processes like requirement alignment verification, multi-scenario system testing, and cross-platform compatibility validation, with an industry average cycle of 6-8 months. However, this study's implementation period lasted merely 9 months (including topic selection, R&D, and writing), during which 10 out of 21 demonstrable software prototypes remained in the certification process without final approval. Secondly, 34.3% of cross-domain topics in the pilot required additional compatibility testing with existing enterprise production systems. Enterprises' heightened risk-averse attitude toward certification standards further extended the verification cycle, objectively reducing the current certification rate.

(2) Core competence cultivation: the four-dimensional competence has achieved remarkable growth

Through the verification of "ability assessment questionnaire (three-party evaluation) + R&D practice assessment + international exchange feedback", the ability score of the pilot group was comprehensively better than that of the control group (Table 5):

The average score of engineering practice ability was 84.2 points, 26.2% higher than that of the control group (66.7 points). 92.2% of the pilot graduate students could independently complete software module development and field debugging (only 51.4% of the control group);

The average score of technological innovation ability was 81.5 points, 29.2% higher than that of the control group (63.1 points), and the number of patent applications was 6 times that of the control group;

The average score of cross-cultural collaboration ability was 80.3, 35.2% higher than that of the control group (59.4), and 81.6% of the pilot graduate students could write a standard English technical abstract (only 22.9% of the control group);

The average score of project management ability was 82.7 points. The completion rate of pilot group papers (including R&D) was 100%, while that of control group was 80.0%.

Table 5: Comparison of core competence scores between pilot group and control group (full score: 100)

Core competency elements	Pilot group mean	Control group mean	Improvement margin
Engineering practice ability (development/Debugging)	84.2	66.7	+26.2%
Technological innovation capability (patent/architecture)	81.5	63.1	+29.2%
Cross-cultural collaboration skills (literature/documents)	80.3	59.4	+35.2%
Project management skills (process/schedule)	82.7	68.3	+21.1%

6 Conclusion

6.1 Research conclusion

The study clarifies the progressive relationship among three dimensions in Master of Engineering (MEng) thesis quality, core competencies, and international competitiveness: Thesis quality serves as the "core vehicle" for competency development. The achievement of its three-dimensional quality objectives— "academic rigor, practical innovation, and global adaptability" —essentially represents the refinement process of core competencies such as engineering practice, technological innovation, and cross-cultural collaboration. Core competencies act as the "key support" for international competitiveness. Data from Tianjin Polytechnic University shows that the pilot group's core competency scores increased by an average of 30.4% compared to the control group. International competitiveness requirements provide "targeted guidance" for enhancing "quality-competency" alignment. By aligning with quality standards from IEEE, ISO/IEC, and other international organizations, the research reversely calibrates key areas for competency development, forming a closed-loop logic of "goal anchoring—competency training—quality enhancement—competitive breakthrough."

The "Three-Dimensional Synergy" dual-enhancement model, grounded in the "goal anchoring-pathway embedding-collaborative safeguarding" framework, has demonstrated remarkable effectiveness through practical implementation in the Computer Technology and Software Engineering programs at Tianjin Polytechnic University. In terms of quality metrics, the pilot group achieved an 85.7% alignment between thesis topics and industry demands, with international standard applications increasing by 31.4% compared to the control group. Regarding competency development, core competencies including engineering practice and cross-cultural collaboration showed over 20% improvement in evaluation scores. This model effectively resolves the longstanding challenge of "quality-competency disconnects" and weak alignment with global competitiveness, establishing a replicable framework for reforming graduation theses in professional degree programs.

Research has confirmed that the tripartite collaboration mechanism involving universities, enterprises, and international organizations serves as a crucial support for dual improvement in "quality and capability". In Tianjin Polytechnic University's practice, enterprise mentors' full participation in R&D guidance resulted in a 37.1% certification rate for achievement enterprises, representing a 33.1 percentage point increase compared to traditional models. Without practical scenarios and technical demands provided by enterprises, the quality of "practical innovation" in academic papers would remain mere talk.

6.2 Research deficiency and prospect

6.2.1 Research deficiencies

First, the study has inherent limitations in sample coverage. The practical validation was limited to computer technology and software engineering programs at Tianjin Polytechnic University, excluding central-western universities and traditional manufacturing disciplines, which necessitates further verification of the model's regional and disciplinary adaptability. Second, the one-year observation period lacks long-term data tracking of graduates' competitiveness performance over 3-5 years post-employment, resulting in insufficient evidence for the model's sustained impact. Third, the research inadequately addresses technological integration in digital transformation contexts, notably omitting explorations of innovative tools like AI-assisted thesis topic selection and blockchain-based achievement certification systems.

6.2.2 Future Prospects

Future research can be advanced through three key approaches: First, expanding the sample scope by selecting universities at various tiers across eastern, central, and western regions (including "Double First-Class" institutions, provincial universities, and industry-specific programs), along with traditional disciplines like mechanical engineering and electrical engineering, to conduct multi-case validation and enhance the model's universality. Second, implementing long-term tracking studies to establish a "Graduate International Competitiveness Database," monitoring the correlation between thesis quality, skill performance, and career development to refine the model's dynamic adjustment mechanism. Third, integrating digital technologies to develop an "Intelligent Topic Matching System" (connecting international industry pain points with student competency profiles) and an "International Collaborative Guidance Platform" (integrating real-time translation and cross-time zone scheduling functions). These innovations will elevate the model's intelligent capabilities, providing more precise support for building world-class engineering talents with enhanced global competitiveness in China's education-driven nation-building efforts.

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