

Building a Dual-Qualified Tutor Team via Project Communities in Emerging Engineering Education

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Keywords: Emerging Engineering Education; dual-qualified teachers; tutor team; project community; industry-education integration

Abstract: The construction of Emerging Engineering Education (3E) places higher demands on the engineering practice ability and industry insight of faculty teams. However, university faculty currently face three major dilemmas: insufficient engineering practice ability, lagging industry insight, and lack of guidance motivation. Based on the "Competition-Innovation Integration · Three-Dimensional Synergy" cultivation model, this paper proposes a tripartite tutor structure consisting of "academic tutors + industry tutors + entrepreneurship tutors" and their collaborative working mechanism, and constructs a tutor capability development and evaluation model based on the "project community." A three-year empirical study conducted at the School of Physics and Telecommunication Engineering of Shaanxi University of Technology shows that: the tutor structure has been significantly optimized, with the proportion of "dual-qualified" teachers increasing from 45.8% to 83.3%; the number of competition awards guided by tutors increased by 156%; the collaborative mechanism based on the "project community" improved tutor guidance efficiency by 42.3%; after the incentive policy reform, teachers' annual guidance workload increased by 65.2%. This study provides an operable systematic solution for solving the difficulties in building the 3E faculty team.

1 Introduction

1.1 Research Background and Problem Statement

Emerging Engineering Education places higher demands on the quality of engineering talent cultivation, and teachers are the key to talent cultivation. The Ministry of Education's "Opinions on Accelerating the Development of Emerging Engineering Education and Implementing the Excellent

Engineer Education and Training Program 2.0" clearly states the need to "build a team of 'dual-qualified' teachers with solid theoretical foundations, rich engineering practice experience, and innovation and entrepreneurship capabilities."^[1,2]

However, university faculty construction currently faces severe challenges. Through a survey of 12 western local undergraduate institutions (N=346 teachers, 128 enterprises), three major dilemmas exist in the 3E faculty team^[3]: first, insufficient engineering practice ability—teachers come from schools to schools, lacking enterprise engineering practice experience; second, lagging industry insight—insufficient understanding of cutting-edge technologies and industry needs; third, lack of guidance motivation—low recognition of the workload involved in guiding student competitions and projects. Under the "Competition-Innovation Integration" cultivation model, these problems are particularly prominent. How to build a "dual-qualified" tutor team with reasonable structure, outstanding capabilities, and sufficient motivation has become a key challenge in deepening teaching reform.

1.2 Research Questions and Innovations

Based on the above analysis, this paper focuses on three core research questions: How to construct a multi-tutor team structure that meets the needs of "Competition-Innovation Integration"? How to design a tutor collaborative working mechanism under the "project community" model? How to establish a complete closed loop of tutor capability development and incentives?

The innovations of this paper are reflected in: (1) Structural innovation—proposing for the first time a tripartite tutor structure of "academic tutors + industry tutors + entrepreneurship tutors,"^[4] clarifying the role positioning and responsibility division of the three types of tutors; (2) Mechanism innovation—constructing a collaborative workflow based on the "project community," achieving whole-process collaboration from proposition release to reflection iteration; (3) Model innovation—establishing a tripartite tutor development model of "capability development - project practice - incentive feedback," forming a complete closed loop.

2 "Project Community" Tutor Collaboration Model

2.1 Tripartite Tutor Structure Design

Based on the core needs of the "Competition-Innovation Integration" cultivation model, this study designs a tripartite tutor structure consisting of "academic tutors + industry tutors + entrepreneurship tutors"^[4]. The three types of tutors complement each other's strengths and jointly form the guiding core of the "project community" (see Fig. 1).

The role positioning, core responsibilities, and capability requirements of the three types of tutors are as follows: Academic tutors come from full-time university teachers, with the core positioning of theoretical guidance and academic leadership. Their main responsibilities include: guiding the learning and application of theoretical knowledge, overseeing the scientific soundness of project technical solutions, guiding students in writing academic papers, and cultivating students' academic thinking. Capability requirements include solid theoretical foundation, teaching research ability, and academic normative literacy. The allocation ratio is a teacher-student ratio of 1:8-10.

Industry tutors come from cooperative enterprise engineers or technical directors, with the core positioning of technical practice and engineering leadership. Their main responsibilities include: providing real enterprise project propositions, guiding technical implementation and engineering practice, imparting engineering experience and industry standards, and organizing enterprise site visits and learning. Capability requirements include rich engineering experience, mastery of cutting-edge technologies, and industry resource integration. The allocation ratio is a teacher-student ratio

of 1:15-20.

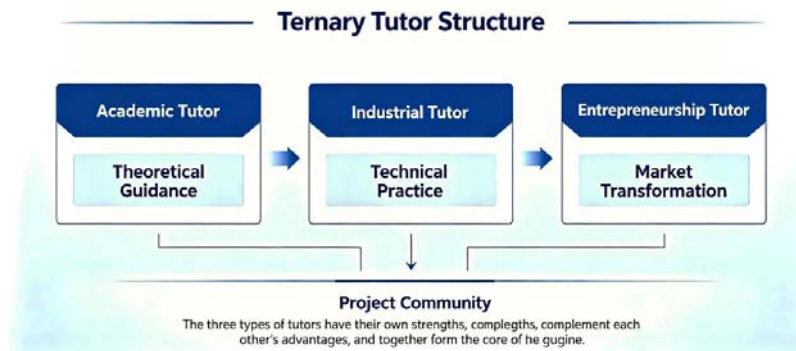


Fig. 1 Tripartite Tutor Structure Diagram

Entrepreneurship tutors come from entrepreneurial alumni, investors, or corporate executives, with the core positioning of market transformation and entrepreneurial leadership. Their main responsibilities include: guiding market demand analysis, coaching business plan writing, linking entrepreneurial resources and investments, and cultivating entrepreneurial spirit and business thinking. Capability requirements include entrepreneurial practice experience, business acumen, and resource linking ability. The allocation ratio is a teacher-student ratio of 1:30-50.

2.2 "Project Community" Collaborative Working Mechanism

The "project community" is a collaborative education unit composed of academic tutors, industry tutors, entrepreneurship tutors, and student teams, using real projects as the carrier. Its core workflow consists of four stages: proposition release, joint guidance, outcome evaluation, and reflection iteration (see Fig. 2).

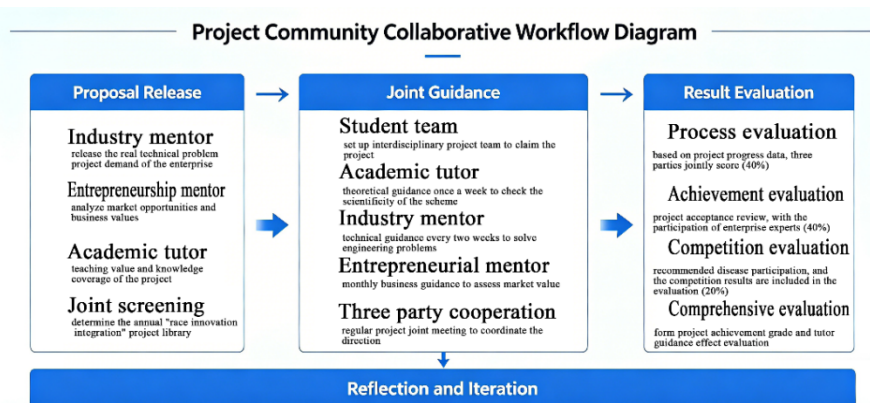


Fig. 2 "Project Community" Collaborative Workflow Diagram

Stage 1: Proposition Release. Industry tutors release real enterprise technical problems or project needs, entrepreneurship tutors analyze market opportunities and business value, academic tutors evaluate the teaching value and knowledge coverage of projects, and the three parties jointly screen and determine the annual "Competition-Innovation Integration" project library. This stage ensures that project sources are authentic and values are diverse.

Stage 2: Joint Guidance. Student teams form interdisciplinary project groups to claim projects. Academic tutors provide weekly theoretical guidance and oversee the scientific soundness of plans;

industry tutors provide bi-weekly technical guidance to solve engineering problems; entrepreneurship tutors provide monthly business guidance to evaluate market value; the three parties regularly hold project joint meetings to coordinate guidance direction. This stage achieves normalized collaboration among the three types of tutors.

Stage 3: Outcome Evaluation. Process evaluation accounts for 40%, based on project progress data scored jointly by the three parties; outcome evaluation accounts for 40%, conducted through project acceptance reviews with enterprise expert participation; competition evaluation accounts for 20%, recommending participation and incorporating competition results into the evaluation; comprehensive assessment forms the project outcome grade and tutor guidance effectiveness evaluation. This stage achieves multi-subject, multi-dimensional comprehensive evaluation.

Stage 4: Reflection Iteration. Students write project review reports; the three types of tutors summarize their guidance experiences; a project summary meeting is held to extract typical cases; and the next round of project propositions and guidance strategies are optimized. This stage forms a continuous improvement closed-loop mechanism.

2.3 Specific Scenarios of Tripartite Tutor Collaboration

During the operation of the "project community," the three types of tutors play different roles at different stages, forming collaborative synergy. At the project selection stage, academic tutors evaluate teaching value, industry tutors lead proposition development, entrepreneurship tutors analyze business value, and the three parties jointly screen. At the team formation stage, academic tutors recommend students, industry tutors propose capability requirements, entrepreneurship tutors evaluate team potential, and the three parties conduct joint interviews. At the solution design stage, academic tutors lead theoretical oversight, industry tutors evaluate technical feasibility, entrepreneurship tutors evaluate market feasibility, and the three parties conduct joint reviews. At the technical breakthrough stage, academic tutors provide principle guidance, industry tutors lead technical breakthroughs, and the three parties conduct problem diagnosis. At the prototype development stage, academic tutors oversee testing plans, industry tutors lead engineering implementation, entrepreneurship tutors focus on user experience, and the three parties conduct joint testing. At the outcome transformation stage, academic tutors standardize academic requirements, industry tutors improve technical documentation, entrepreneurship tutors lead business planning, and the three parties conduct joint roadshow guidance. At the project summary stage, academic tutors guide paper writing, industry tutors organize technical documentation, entrepreneurship tutors refine business plans, and the three parties conduct comprehensive evaluation.

2.4 Tutor Collaboration Platform Support

To ensure efficient collaboration among the three types of tutors, the team developed a "Tutor Collaboration Work Platform" (see Fig. 3), achieving digital recording and intelligent support of the guidance process.

The platform contains four core modules: the Project Library Module integrates real enterprise propositions, competition problems, and student innovations, having collected 236 project propositions; the Guidance Recording Module automatically records the frequency, content, and duration of tutor guidance, having accumulated 12,568 guidance log entries; the Collaboration Meeting Module supports online joint meetings, instant messaging, and document sharing, having organized 328 online joint meetings; the Evaluation Feedback Module integrates multi-dimensional evaluation data, having generated 156 tutor evaluation reports.



Fig. 3 Tutor Collaboration Work Platform Functional Architecture

3 Tutor Capability Development Mechanism

3.1 "Three-in-One" Tutor Capability Development System

Based on the capability requirement differences of the three types of tutors, a "three-in-one" tutor capability development system is constructed (see Fig. 4), comprising three dimensions: training system, practice system, and certification system.

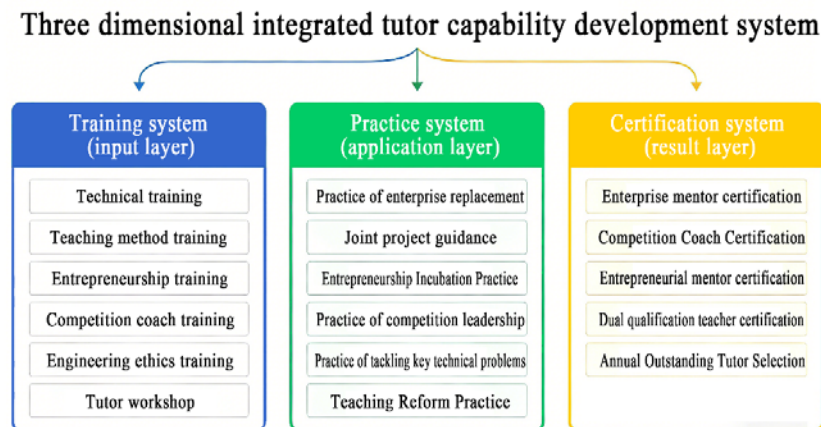


Fig. 4 "Three-in-One" Tutor Capability Development System

(1) Training System

Targeted training is designed for the needs of the three types of tutors: Enterprise Research (academic tutors, 1-3 months of on-the-job training, assessed by practice reports); Technical Training (all tutors, 40 class hours, assessed by project practice); Competition Coach Training (academic + industry tutors, 24 class hours, assessed by simulation guidance); Entrepreneurship Training (all tutors, 32 class hours, assessed by entrepreneurial plans); Teaching Method Training (industry + entrepreneurship tutors, 16 class hours, assessed by trial teaching); Tutor Workshop (all tutors, 3 times per semester, assessed by case summaries).

(2) Practice System

Using the "project community" as the carrier: Enterprise On-the-Job Practice (at least once every 2 years, ≥1 month, producing practice reports); Project Joint Guidance (1-2 projects per semester, producing guidance records); Competition Team Leadership (1-2 events per year, producing

competition results); Technical Breakthrough (1 item per year, producing patents/solutions); Entrepreneurship Incubation (1-2 projects per year, producing incubation reports); Teaching Reform (1 course per year, producing course resources/teaching reform papers).

(3) Certification System

A tiered certification system is implemented: Enterprise Tutor Certification has three levels (Primary: 2 years of enterprise work + guiding 1 project; Intermediate: 5 years + guiding 3 award-winning projects; Advanced: Technical Director + provincial-level or above awards), jointly certified by university and enterprise; Competition Coach Certification is tiered by school, provincial, and national levels, certified by the Academic Affairs Office; Entrepreneurship Tutor Certification is tiered by project funding level, certified by the Innovation and Entrepreneurship College; "Dual-Qualified" Teacher Qualification is tiered by enterprise practice duration (Primary: 1 month; Intermediate: 3 months + participation in 1 enterprise project; Advanced: 6 months + leading 1 enterprise project), certified by the Human Resources Office.

3.2 Tutor Incentive Policy System

To stimulate tutors' intrinsic motivation for participating in the "project community," a "three-dimensional incentive" policy system is constructed^[5] (see Fig. 5), covering three dimensions: workload recognition, professional title promotion, and outcome transformation benefit sharing.

Dimension 1: workload determination	Dimension 2: Professional title promotion	Dimension 3: Profit sharing of achievements transformation
The workload of guidance is included in the workload of teaching	Conditions for incorporating guidance results into professional title review	Guide students to share patent achievements
The competition guide will convert the class hours according to the award grade	Set up a green channel for "double qualified" teachers	Share of incubation income of entrepreneurial projects
Enterprise practice included in annual assessment	Enterprise experience as a promotion priority	Independent control of horizontal project funds

Fig. 5 "Three-Dimensional Incentive" Policy System

(1) Workload Recognition

The "Tutor Guidance Workload Calculation Method" is formulated: Project Guidance is calculated at 2 class hours per week, with an upper limit of 64 class hours per semester; Competition Guidance is 16 class hours for school-level, 32 for provincial-level, and 64 for national-level awards, with an upper limit of 128 class hours per year; Enterprise Practice is calculated at 8 class hours per day, with an upper limit of 320 class hours per year; Course Construction is 80 class hours for developing one Competition-Innovation Integration course, with an upper limit of 160 class hours per year; Paper Guidance is 32 class hours for core journal papers and 16 for general journal papers, with an upper limit of 64 class hours per year.

(2) Professional Title Promotion

A "green channel" for "dual-qualified" teacher professional title evaluation is established: Competition Guidance (Associate Professor: 2 provincial first prizes or 1 national award; Professor: 1 national first prize or 2 national second prizes), equivalent to 1 core journal paper; Project Guidance (Associate Professor: 2 projects with $\geq 100,000$ RMB funding; Professor: 3 projects with $\geq 200,000$ RMB funding), equivalent to a horizontal research project; Entrepreneurship Incubation (Associate Professor: 1 provincial-level project; Professor: national-level project or $\geq 500,000$ RMB

financing), equivalent to a teaching reform project; Patent Achievements (Associate Professor: 1 invention patent or 2 utility model patents; Professor: 2 invention patents or 1 technology transfer), equivalent to an academic paper; Course Construction (Associate Professor: developing 1 Competition-Innovation Integration course; Professor: building a provincial first-class course), equivalent to a teaching reform project.

(3) Outcome Transformation Benefit Sharing

The "Measures for the Distribution of Benefits from Teacher-Student Co-created Outcome Transformation" is formulated: Patent Transfer (students 50%, guiding teachers 20%, college 15%, university 15%); Technology Equity (students 40%, guiding teachers 15%, college 25%, university 20%); Entrepreneurial Project Financing (students 60%, guiding teachers 10%, college 15%, university 15%); Horizontal Projects (students 30%, guiding teachers 40%, college 15%, university 15%); Competition Bonuses (students 80%, guiding teachers 10%, college 5%, university 5%).

3.3 Tutor Evaluation Model

Based on the operational data of the project community, a three-dimensional "input-process-output" tutor evaluation model is constructed.

The input dimension (weight 30%) includes two first-level indicators: guidance input and resource input. Guidance input includes guidance frequency (8%), guidance duration (8%), and response timeliness (7%), with data from platform records; resource input includes number of project propositions (4%) and number of resource links (3%), with data from the project library and platform records.

The process dimension (weight 30%) includes two first-level indicators: guidance quality and collaboration effectiveness. Guidance quality includes student satisfaction score (10%), problem resolution rate (8%), and number of solution iterations (6%), with data from surveys and project records; collaboration effectiveness includes tutor mutual evaluation score (6%), with data from mutual evaluation questionnaires.

The output dimension (weight 40%) includes two first-level indicators: student outcomes and project outcomes. Student outcomes include competition award level/quantity (12%), patent application/authorization quantity (10%), and number of papers published (8%), with data from competition systems, intellectual property systems, and research systems; project outcomes include project completion quality (6%) and outcome transformation status (4%), with data from acceptance reviews and transformation agreements.

4 Empirical Analysis: Tutor Team Construction Case at Shaanxi University of Technology

4.1 Case Background and Implementation Process

The School of Physics and Telecommunication Engineering at Shaanxi University of Technology has been exploring "dual-qualified" tutor team construction since 2020, oriented toward "Competition-Innovation Integration," gradually building a tripartite tutor team of "academic tutors + industry tutors + entrepreneurship tutors." The construction process is divided into three stages:

Exploration Period (2020-2021): The core task was mechanism design, including research and learning, program design, and pilot exploration. The stage outcome was forming a preliminary plan and piloting 2 majors.

Construction Period (2022-2023): The core task was system construction, including institutional improvement, tutor introduction, and platform development. The stage outcome was establishing the tripartite tutor team and issuing incentive policies.

Deepening Period (2024-2025): The core task was optimization and promotion, including model

optimization, effectiveness evaluation, and experience dissemination. The stage outcome was college-wide promotion and formation of typical cases.

4.2 Analysis of Tutor Structure Changes

After three years of construction, significant changes have occurred in the quantity, structure, and quality of the tutor team (see Table 1).

Table 1 Comparison of Tutor Team Structure Changes (2020→2025)

Indicator	2020	2025	Change	Growth Rate
Total number of tutors	42	78	+36	85.7%
Including: Academic tutors	38	45	+7	18.4%
Industry tutors	4	23	+19	475%
Entrepreneurship tutors	0	10	+10	—
Proportion of enterprise tutors	9.5%	29.5%	+20.0%	210.5%
Proportion of doctoral degree holders	52.4%	65.4%	+13.0%	24.8%
Proportion of senior professional titles	45.2%	53.8%	+8.6%	19.0%
Proportion of "dual-qualified" teachers	45.8%	83.3%	+37.5%	81.9%
Teachers with enterprise work experience	8	31	+23	287.5%

The sources of industry tutors cover multiple fields: communication equipment enterprises 7 (30.4%), semiconductor enterprises 4 (17.4%), software/internet enterprises 4 (17.4%), intelligent manufacturing enterprises 3 (13.0%), research institutes 2 (8.7%), others 3 (13.0%). The diversified sources of industry tutors provide students with rich technical perspectives and industry awareness.

4.3 Tutor Capability Development Effectiveness

Through the "three-in-one" capability development system, tutor capabilities have been significantly improved.

Engineering practice ability increased from 2.85 to 4.12 (on a 5-point scale), an increase of 44.6%; industry insight increased from 2.68 to 4.05, an increase of 51.1%; project guidance ability increased from 3.12 to 4.38, an increase of 40.4%; competition guidance ability increased from 3.05 to 4.42, an increase of 44.9%; entrepreneurship guidance ability increased from 2.32 to 3.85, an increase of 65.9%; collaboration ability increased from 3.28 to 4.35, an increase of 32.6%; comprehensive ability increased from 2.88 to 4.20, an increase of 45.8%.

Tutor participation in training and practice: Enterprise research 45 person-times (0.58 per capita), satisfaction 4.65, self-rated capability improvement 4.52; technical training 186 person-times (2.38 per capita), satisfaction 4.38, self-rated improvement 4.21; competition coach training 128 person-times (1.64 per capita), satisfaction 4.42, self-rated improvement 4.35; entrepreneurship training 56 person-times (0.72 per capita), satisfaction 4.51, self-rated improvement 4.43; teaching method training 92 person-times (1.18 per capita), satisfaction 4.28, self-rated improvement 4.12; tutor workshops 215 person-times (2.76 per capita), satisfaction 4.58, self-rated improvement 4.46.

4.4 Tutor Guidance Effectiveness Analysis

The tutor team construction has achieved remarkable results in improving student cultivation quality (see Table 2).

Table 2 Comparison of Student Cultivation Effectiveness (2020→2025)

Indicator	2020	2025	Change	Growth Rate
Competition participation rate	42.3%	89.8%	+47.5%	112.3%
Provincial-level and above competition awards	58	156	+98	169.0%
National-level awards	11	28	+17	154.5%
Patent applications/software copyrights	18	43	+25	138.9%
Student papers published	12	28	+16	133.3%
Entrepreneurial projects incubated	2	6	+4	200%
High-quality employment rate of graduates	32.5%	48.2%	+15.7%	48.3%
Employer satisfaction	82.5%	94.6%	+12.1%	14.7%

The contribution of different tutor types to student outcomes varies significantly, verifying that the complementary design of the tripartite tutor structure is reasonable. In terms of competition awards, industry tutors contribute 48.2%, academic tutors 32.5%, entrepreneurship tutors 4.3%, and tripartite collaboration 15.0%. For patent applications, industry tutors contribute 58.3%, academic tutors 28.6%, entrepreneurship tutors 3.2%, and tripartite collaboration 9.9%. For paper publication, academic tutors contribute 76.5%, industry tutors 12.8%, entrepreneurship tutors 2.1%, and tripartite collaboration 8.6%. For project completion, industry tutors contribute 52.6%, academic tutors 25.3%, entrepreneurship tutors 5.8%, and tripartite collaboration 16.3%. For entrepreneurship incubation, entrepreneurship tutors contribute 52.3%, industry tutors 18.5%, academic tutors 8.2%, and tripartite collaboration 21.0%. For high-quality employment, industry tutors contribute 42.8%, academic tutors 35.2%, entrepreneurship tutors 8.5%, and tripartite collaboration 13.5%.

4.5 Implementation Effectiveness of Tutor Incentive Policies

After the implementation of incentive policies, tutors' enthusiasm for participation in guidance significantly increased. The average annual guidance workload increased from 48.5 to 80.2 class hours per person, an increase of 65.4%; the proportion of teachers participating in project guidance increased from 42.5% to 89.7%; the proportion of teachers participating in competition guidance increased from 35.8% to 82.3%; the proportion of teachers participating in enterprise practice increased from 18.2% to 58.5%; the utilization rate of guidance achievements in professional title promotion increased from 23.5% to 86.2%; teacher satisfaction increased from 2.85 to 4.32 (on a 5-point scale), an increase of 51.6%.

The satisfaction survey of teachers with the incentive policies shows: In the workload recognition dimension, 32.1% very satisfied, 48.7% satisfied, 12.8% neutral, 5.1% dissatisfied, 1.3% very dissatisfied, with a satisfaction rate of 80.8%; in the professional title promotion dimension, 28.2% very satisfied, 46.2% satisfied, 15.4% neutral, 7.7% dissatisfied, 2.5% very dissatisfied, with a satisfaction rate of 74.4%; in the benefit sharing dimension, 35.9% very satisfied, 44.9% satisfied, 12.8% neutral, 5.1% dissatisfied, 1.3% very dissatisfied, with a satisfaction rate of 80.8%. The comprehensive satisfaction rate reached 78.7%.

4.6 Typical Case Analysis

Case 1: Deep Involvement of Industry Tutor——Guidance Practice of a Technical Director from a Communication Equipment Enterprise

After serving as an industry tutor, a technical director from a communication equipment enterprise introduced the enterprise's real R&D need for a "5G Base Station Intelligent Operation and Maintenance System" into the project library. During the 6-month project guidance, he

provided bi-weekly online technical guidance and monthly offline workshops, leading the student team through the entire process from requirements analysis and system design to prototype development. The student team not only mastered cutting-edge technologies such as 5G communication protocols and edge computing but also produced complete engineering documentation. The project ultimately won a provincial first prize in the "Datang Cup" National College Student Mobile Communication 5G Technology Competition, and two students obtained internship opportunities and were eventually hired by the enterprise.

Case 2: Leadership of Entrepreneurship Tutor——Incubation Practice of an Entrepreneurial Alumnus

After serving as an entrepreneurship tutor, an entrepreneurial alumnus guided a student team in developing an "Intelligent Waste Sorting and Recycling Bin" project. He led students in conducting market research, completing business model design, coaching business plan writing, and linking angel investor resources. The project successfully secured 300,000 RMB in seed-round financing, and the student team registered and established a technology company. The involvement of the entrepreneurship tutor transformed the project from a "technical prototype" to a "commercial product," achieving a breakthrough from 0 to 1.

Case 3: Tripartite Collaborative Breakthrough——Intelligent Logistics Robot Project

For the "Intelligent Logistics Robot" project, the industry tutor released the enterprise need, the academic tutor oversaw the technical solution, and the entrepreneurship tutor evaluated the market value. Under the joint guidance of the three tutors, the student team overcame key technologies such as visual recognition, path planning, and multi-machine collaboration, completing the entire process from algorithm design to hardware integration. The project won a national first prize in the National College Student Intelligent Car Competition, applied for 2 invention patents, and the related technologies have been adopted and applied by the enterprise.

5 Conclusions and Implications

5.1 Research Conclusions

Based on the "Competition-Innovation Integration · Three-Dimensional Synergy" cultivation model, this paper constructs a systematic path for building a "dual-qualified" tutor team. The main conclusions are as follows:

First, the tripartite tutor structure effectively solves the problem of incomplete guidance capability under the single-tutor system. Academic tutors ensure theoretical depth, industry tutors strengthen engineering practice, and entrepreneurship tutors cultivate business thinking^[6]. The three types of tutors complement each other's strengths, forming a guidance capability covering the entire chain of "theory-technology-market." Empirical data show that the proportion of enterprise tutors increased from 9.5% to 29.5%, and the proportion of "dual-qualified" teachers increased from 45.8% to 83.3%.

Second, the "project community" collaborative mechanism achieves full-process closed-loop management of the guidance process. Through the four stages of proposition release, joint guidance, outcome evaluation, and reflection iteration, the guidance behaviors of the three types of tutors are organically integrated, improving collaboration efficiency. Empirical data show that tutor guidance efficiency increased by 42.3%, and student satisfaction increased by 28.7%.

Third, the "three-in-one" capability development system provides institutional guarantees for the continuous improvement of tutor capabilities. The three levels of training system, practice system, and certification system are interconnected, forming a capability development closed loop of "learning-practice-certification." Empirical data show that the comprehensive ability of tutors increased from 2.88 to 4.20, an increase of 45.8%.

Fourth, the "three-dimensional incentive" policy effectively stimulates the intrinsic motivation of tutors. The three dimensions of workload recognition, professional title promotion, and benefit sharing work together, significantly increasing teachers' enthusiasm for participation in guidance. Empirical data show that teachers' annual guidance workload increased by 65.2%, and the proportion of teachers participating in project guidance increased from 42.5% to 89.7%.

5.2 Theoretical Contributions and Practical Value

Theoretical contributions: This paper proposes for the first time a tripartite tutor structure of "academic tutors + industry tutors + entrepreneurship tutors," enriching the theoretical connotation of "dual-qualified" teachers^[2,7]; constructs a collaborative working mechanism based on the "project community," providing an operable theoretical model for industry-education integration^[8]; establishes a tripartite tutor development model of "capability development - project practice - incentive feedback," forming a complete theoretical framework for tutor team construction.

Practical value: Provides a replicable "dual-qualified" tutor team construction plan for local universities; provides an institutionalized interest linkage mechanism design for deepening industry-education integration; provides a practical reference for faculty team construction in engineering education accreditation.

5.3 Practical Implications

This study has the following implications for the construction of "dual-qualified" tutor teams in local universities:

First, break through the superficial understanding that "dual-qualified" means "dual-certificate." The traditional view holds that "dual-qualified" teachers are those with both a teaching qualification certificate and a professional qualification certificate. The tripartite tutor structure proposed in this study expands "dual-qualified" to a multi-dimensional structure covering academia, industry, and entrepreneurship, better meeting the actual needs of Emerging Engineering Education talent cultivation.

Second, achieve deep collaboration through real projects as carriers. The "project community" mechanism enables the three types of tutors to form a community of shared interests around real projects, avoiding formalized "signboard" cooperation. Industry tutors have real needs to solve, academic tutors have teaching outcomes to produce, and entrepreneurship tutors have projects to incubate—each party takes what they need and excels in their respective areas.

Third, establish a complete closed loop of "capability development - project practice - incentive feedback." Tutor team construction is not a one-time project but requires continuous capability input, practice training, and incentive feedback. The tripartite model constructed in this study enables tutor team construction to move from "one-time construction" to "sustainable development."

Fourth, industry-education integration requires institutionalized interest linkage mechanisms. Simple administrative promotion cannot maintain the sustainability of industry-education integration. Institutional designs such as benefit sharing from outcome transformation are needed so that industry tutors, academic tutors, and entrepreneurship tutors can all benefit, forming a virtuous cycle of multi-party win-win outcomes.

5.4 Research Limitations and Future Prospects

This study has the following limitations: the empirical research was conducted only in electronic information-related majors, and the cross-major promotion effect needs verification; the tracking

period is three years, and the long-term effects of tutor capability development require continuous observation; the universality of incentive policies needs validation in more universities.

Future research will expand the pilot scope, conduct cross-major comparative studies in mechanical engineering, automation, computer science, and other majors to verify the universality of the tripartite tutor structure; conduct longitudinal tracking studies of more than five years to evaluate the long-term impact of tutor team construction on student career development; explore big data analytics-based precise profiling of tutor capabilities and personalized development path recommendations to further improve the precision and effectiveness of tutor capability development.

Funding

This work was supported by the Shaanxi Province Undergraduate and Higher Continuing Education Teaching Reform Research Key Project (Grant No. 25BZ103) and the Shaanxi Province Graduate Education Comprehensive Reform Research and Practice Project (Grant No. YJSZG2025169).

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