

Optimization Path of Vocational Education and "Double-Qualified" Teacher Team Construction from the Perspective of Industry-Education Integration

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ABSTRACT Deepening industry-education integration is a key path for improving vocational education quality and cultivating “double-qualified” teachers with both theoretical knowledge and practical engineering competence. Based on human capital theory and collaborative governance theory, this study uses literature research, questionnaire survey, and case analysis to systematically examine the current characteristics, practical dilemmas, and causal mechanisms of “double-qualified” teacher team construction under the background of industry-education integration. The results show that current teacher teams face problems such as an imperfect school-enterprise collaborative training mechanism, weak practical teaching capability, imbalanced evaluation and incentive systems, and insufficient resource guarantees. Drawing on typical cases of pilot vocational colleges and industrial colleges, this paper constructs a “four-in-one” path optimization framework covering institutional guarantee, training model, evaluation mechanism, and resource integration. Specific strategies are proposed to improve long-term cooperation among schools, enterprises, industries, and government departments. The study provides a systematic framework for strengthening vocational teacher development, improving practical teaching quality, and supporting talent cultivation for advanced engineering and intelligent manufacturing fields.

INDEX TERMS industry-education integration, vocational education, double-qualified teachers, path optimization, teacher development

I. INTRODUCTION

A. RESEARCH BACKGROUND

VOCATIONAL colleges still struggle to meet the development needs of enterprises in talent training, resulting in a mismatch between supply and demand—an awkward situation where the supply side of talents faces employment difficulties while the demand side faces talent shortages [1]. The development of industry-education integration has promoted the transformation and upgrading of the demand for talent training in higher vocational education. Industry-education integration “promotes education through industry” and “boasts industry through education”, achieving an effective combination of the two [2]. Therefore, the joint development and collaborative talent training between vocational colleges and industries are an critical approach to cultivating technical talents needed for social development and industrial enterprises [3]. As a key channel for cultivating technical talents for industries, vocational colleges

demonstrate their talent training capabilities. Teachers are important educators in vocational colleges, and the requirements of industry-education integration for vocational colleges are also translated into requirements for teachers, who must continuously develop and learn to adapt to the new impacts and changes brought by industry-education integration [4]. The development of “double-qualified” teachers has become an pressing priority, and it is necessary to break the original teaching model to cultivate technical talents that meet industrial demands [5, 6].

Promoting the long-term and scientific development of “double-qualified” teacher teams in vocational colleges is beneficial to schools, students, teachers, and enterprises [7]. For schools, the ultimate goal of developing “double-qualified” teachers is to serve the development of vocational colleges. Teachers are the main body of schools and the premise for their development [8]. A healthy, effective, sustainable teacher team that meets the needs of social devel-

opment is a key support for the continuous development of schools. For students, “double-qualified” teachers can impart practical and efficient professional knowledge, effectively reconcile the contradiction between theory and practice, and enable students to integrate theoretical and practical knowledge [9]. For teachers, building a scientific “double-qualified” teacher team can promote their own development and continuously strengthen their theoretical knowledge and practical skills [10]. For enterprises, the construction of “double-qualified” teacher teams is an important way for enterprises to exert their subjectivity in participating in vocational education, an effective connection between enterprise needs and higher vocational education, and an important expression of enterprises’ cross-border linkage with higher vocational education [11].

Under the current background of industry-education integration, there is still room for further deepening the construction of “double-qualified” teacher teams. On the one hand, after years of development in the construction of “double-qualified” teacher teams in vocational colleges, various problems remain unresolved, and there are confusions both in the conceptual system and operational level of teacher team construction [12]; on the other hand, in the current process of school-enterprise integration, various indicator tasks mainly focus on teaching hardware, practical environments, and employment platforms, while measures for other multiple subjects to participate in teacher team construction are slightly insufficient [13]. Therefore, exploring the optimization path for “double-qualified” teacher teams through the lens of industry-education integration holds profound theoretical value and practical significance for technologies. This approach ensures that the development of teaching staff directly addresses the technical complexities and evolving innovation requirements inherent in the high-end industry.

B. RESEARCH STATUS

Scholars have conducted research on the connotation of industry-education integration and the significance of industry-education integration in vocational education. As one of the main human resource supply sides for China’s economic and social development, the distorted allocation of elements such as majors, courses, and teachers in vocational education has led to structural imbalances on the supply side of vocational education. Deepening industry-education integration is an inevitable requirement and basic path for realizing supply-side reform in the field of education. The elevation of industry-education integration from a vocational education policy to a national strategy is not only a realistic need for national strategy and technological transformation and upgrading but also an important way for the high-quality development of higher vocational education itself [14].

Regarding policies on industry-education integration in vocational education, studies have shown that in the process of implementing industry-education integration, there are practical dilemmas such as poor pertinence, inadequate

timeliness, and an imperfect policy system, and proposed solutions [15]; comparing the basic characteristics of foreign vocational education industry-education integration policies, China’s vocational education industry-education integration policies still need to be continuously improved in terms of system construction, coordination and linkage, incentive guarantees, etc [16].

Regarding the mechanism of industry-education integration in vocational colleges, based on explaining the concept of industry-education integration, Yang Yunxin (2014) proposed that the in-depth industry-education integration at the operational level still needs to establish and improve relevant overall supervision mechanisms, legal guarantee mechanisms, incentive and compensation mechanisms, diversified allocation mechanisms, coordination and linkage mechanisms, and quality evaluation mechanisms [17]. On the basis of analyzing the main problems existing in current vocational education industry-education integration, Xie Meicheng proposed innovative ideas for the vocational education industry-education integration system and mechanism, such as building a multi-participatory industry-education integration platform involving government, industry, schools, and enterprises to promote school-enterprise cooperation, and establishing effective interest balance mechanisms, diversified resource allocation mechanisms, and communication and coordination mechanisms [18]. Liu Lixin (2015) summarized the experience of German industry-education integration practices, summed up the three characteristics of German industry-education integration: authority, operability, and effectiveness, and provided certain theoretical experience for China’s vocational education industry-education integration [19].

Regarding the models and paths of industry-education integration, from the perspective of production methods, Hu Changsong et al. believe that industry-education integration is essentially the arrangement of different types of knowledge production methods, a development method that moves from resource cooperation to knowledge production cooperation, and carries out integration in terms of resources, culture, and needs [20]. Wang Baoyu pointed out that the main participants of industry-education integration should include government, industry, schools, enterprises, and intermediaries, and develop collaboratively, while the carriers for the in-depth development of industry-education integration include 10 major contents such as talents, projects, systems, and information.

The qualification recognition standards for “double-qualified” teachers determine the entry threshold for teachers. Li Mengqing and others have conducted a lot of relevant research, believing that qualification certification standards for teachers should be formulated based on the construction of “double-qualified” teacher teams and the quality of technical talent training, while practical skills, moral norms, and teaching capabilities are macro-level norms and basic requirements, and also include content such as professional spirit, on-the-job technology, and association certification.

Li Dongxue believes that there are still many problems with “double-qualified” teachers, and the key to solving the problems is to promote the construction of teacher teams through mechanisms, establish teacher growth mechanisms, and meet the professional development needs of teachers. The growth mechanism should cover entry, development, and exit mechanisms to promote the growth of teacher teams. Zhang Zhiqiang attaches importance to the role of construction mechanisms, promotes the development of “double-qualified” teacher teams through mechanisms, and further proposes mechanisms oriented by construction goals, talent development, and teacher assessment and evaluation.

C. RESEARCH CONTENT AND METHODS

1) Research Content

1) Analysis of the internal logical relationship between industry-education integration and the construction of “double-qualified” teacher teams;

2) Investigation on the current situation and problems of “double-qualified” teacher team construction under the background of industry-education integration;

3) Analysis of the causal mechanism of the dilemmas in “double-qualified” teacher team construction;

4) Path optimization and strategy proposal for “double-qualified” teacher team construction from the perspective of industry-education integration.

2) Research Methods

1) Literature Research Method:

First, the study conducts research on relevant literature on industry-education integration in vocational colleges and the construction of “double-qualified” teacher teams. Secondly, through the collection and collation of policy documents, meetings, and academic articles from the Ministry of Education and relevant domestic policy websites, a theoretical foundation is laid for subsequent research.

2) Questionnaire Survey Method:

An exclusive questionnaire is designed to conduct empirical research on “double-qualified” teachers, aiming to analyze the prominent problems in the practical teaching evaluation of “double-qualified” teachers in higher vocational education.

3) Case Study Method: Three industry-education integration pilot units, such as a vocational and technical college in Jiangsu Province and an industrial college in Guangdong Province, are selected as research objects to conduct an in-depth analysis of the experience and enlightenment in the construction of “double-qualified” teacher teams.

4) Interview Method:

In-depth interviews are conducted with teachers from relevant vocational colleges, human resource directors of enterprises, and responsible persons of educational administrative departments.

A. INDUSTRY-EDUCATION INTEGRATION

The concept of “industry-education integration” first appeared in the policy document “Decision of the Central Committee of the Communist Party of China on Several Major Issues Concerning Comprehensively Deepening Reform” issued by the state in 2013, but expressions related to industry-education integration have a long history. In the past more than 20 years, the education circle has used various expressions: such as “school-enterprise cooperation”, “production-education cooperation”, and “integration of production and education”. The emergence of the concept of “industry-education integration” is based on the aforementioned concepts, and “integration” is deeper than “combination”, emphasizing more on unity. Compared with the traditional “school-enterprise cooperation” model which focuses on project-based collaboration, resource sharing, and talent delivery, this paper defines “industry-education integration” as an organic interactive state of circulation and integration of various elements between the industrial and educational systems, with three core distinguishing features: 1) Systematic coupling: realizing the deep alignment of industrial development goals, technical standards, and talent demands with the educational positioning, curriculum systems, and training objectives of vocational colleges; 2) Symbiotic governance: establishing a long-term mechanism involving joint decision-making, responsibility sharing, and benefit co-creation among government, industry, schools, and enterprises, rather than one-way participation of enterprises in school education; 3) Dynamic circulation: forming a closed loop of “industrial demand feedback - educational reform - talent output - industrial upgrading”, which promotes the mutual promotion and coordinated development of education and industry. At the macro level, the connotation of industry-education integration represents the coupling between the development vision of the country and regions and the goals of educational development. Vocational education shoulders the expectations of national and regional social development and is based on industrial development.

B. “DOUBLE-QUALIFIED” TEACHERS

“Double-qualified” teachers must possess two professional characteristics, accomplishments, and personality traits at the same time, and become educators who can integrate “dual” qualities of professional theoretical literacy and professional practical ability. In the context of the new era, “double-qualified” teachers should be endowed with new connotations. In higher vocational colleges, whether a teacher has “double-qualified” qualities has become a key criterion for measuring their professional competence. The “double-qualified” teachers mentioned in this paper are not only interdisciplinary talents combining teaching ability and professional practical operation skills but also hold nationally recognized higher education teacher qualification certificates and professional qualification certificates related to teaching majors, including both full-time teachers of the

II. DEFINITION OF CORE CONCEPTS

school and part-time teachers from enterprises.

III. CURRENT SITUATION AND PROBLEMS OF “DOUBLE-QUALIFIED” TEACHER TEAM CONSTRUCTION UNDER THE BACKGROUND OF INDUSTRY-EDUCATION INTEGRATION

A. OVERVIEW OF CURRENT SITUATION INVESTIGATION

To fully understand the current situation of “double-qualified” teacher team construction under the background of industry-education integration, this paper selects 20 vocational colleges in 10 provinces across the country to conduct a questionnaire survey. The selection of the sample colleges adopts a stratified sampling method based on three dimensions: regional distribution (eastern, central, and western regions), schoolrunning level (national “Double High-Level” vocational colleges, provincial key vocational colleges, and general vocational colleges), and professional type. This sampling method ensures that the sample covers different levels and types of vocational colleges, enhancing the representativeness of the research results. A total of 850 questionnaires were distributed in this survey, 786 valid questionnaires were recovered, with an effective recovery rate of 92.59%.

At the same time, 3 industry-education integration pilot colleges are selected for case investigation, and in-depth interviews are conducted with some teachers, enterprise representatives, and educational managers. The research content covers the quantity structure, ability quality, training, evaluation, and incentive of “double-qualified” teachers. This study was approved by the Ethics Committee of Hunan Vocational College of Engineering, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

B. PROMINENT PROBLEMS

1) Imperfect School-Enterprise Collaborative Training Mechanism

- Shallow Cooperation Level:

Most school-enterprise cooperations are still at the level of short-term cooperation and project cooperation, lacking long-term and stable strategic cooperative relationships, and enterprises have low enthusiasm for participating in the training of “double-qualified” teachers.

- Unclear Division of Responsibilities:

The responsibilities, rights, and obligations of both schools and enterprises in teacher training are not clearly defined, leading to buck-passing phenomena during the training process.

- Insufficient Resource Integration:

The technical, equipment, and teacher resources of enterprises have not been effectively integrated and shared with the educational resources of vocational colleges, resulting in serious waste of training resources.

2) Weak Practical Teaching Capabilities

- Lack of Practical Experience:

Most “double-qualified” teachers lack work experience at the front line of enterprises, their practical operation skills are not proficient, and they are unable to meet the needs of practical teaching.

- Low Level of Practical Training Teaching:

Some teachers lack practical teaching methods and skills, making it difficult to effectively organize practical training teaching activities, and the quality of practical training teaching needs to be improved.

- Insufficient Grasp of Industry Trends:

Teachers have few opportunities to participate in industry training and technical exchanges, and their understanding of industry development trends, new technologies, and new processes is not timely, resulting in lagging updates to teaching content.

3) Imbalanced Evaluation and Incentive System

- Unreasonable Evaluation Standards:

The evaluation standards emphasize theory over practice and academic qualifications over abilities, failing to fully reflect the core characteristics of “double-qualified” teachers.

- Single Evaluation Subject:

The evaluation subject is mainly the school, lacking the participation of third-party subjects such as enterprises and industry associations, and the evaluation results are not objective and fair enough.

- Imperfect Incentive Mechanism:

The incentive methods are single, focusing on material incentives, lacking spiritual incentives and career development incentives; the incentive intensity is insufficient, making it difficult to fully mobilize the enthusiasm and initiative of teachers.

4) Insufficient Resource Guarantee

- Insufficient Funding Input:

The average proportion of training funds for “double-qualified” teachers in sample colleges to educational funds is only 3.2%. The shortage of funds makes it difficult to effectively carry out training activities.

- Lagging Construction of Practical Training Bases:

The equipment in the practical training bases of some colleges is outdated and insufficient in quantity, making it difficult to meet the needs of teachers’ practical training and students’ practical training teaching.

- Rigid Teacher Management System:

The institutional mechanisms such as teacher establishment management and professional title evaluation in vocational colleges are relatively rigid, making it difficult to attract enterprise technical talents to join the teacher team and restricting the career development of existing teachers.

C. ANALYSIS OF CAUSAL MECHANISMS

Institutional Level: Imperfect Policy Support and Guarantee System

- Lack of a unified national recognition standard and management method for “double-qualified” teachers.

The recognition standards vary from region to region and from school to school, resulting in uneven quality of “double-qualified” teachers.

- The relevant policies on industry-education integration lack rigid constraints, and the incentive policies for enterprises to participate in the training of “double-qualified” teachers are not perfect, leading to insufficient motivation for enterprises to participate.
- The reform of the teacher management system in vocational colleges lags behind, and policies such as establishment management and professional title evaluation are difficult to adapt to the needs of “double-qualified” teacher team construction.

College Level: Inadequate Implementation of Main Responsibilities

- Some vocational colleges do not fully recognize the importance of “double-qualified” teacher team construction and lack systematic construction plans and implementation plans.
- The cooperation between colleges and enterprises lacks initiative and innovation, and fails to effectively integrate enterprise resources to serve the training of “double-qualified” teachers.
- The teacher training system is imperfect, the training content is disconnected from industrial needs, and the training methods lack pertinence and effectiveness.

Enterprise Level: Insufficient Participation Motivation and Capability

- Enterprises are profit-oriented. Participating in the training of “double-qualified” teachers requires investing a lot of human, material, and financial resources, and direct economic benefits are difficult to obtain in

the short term, resulting in low participation enthusiasm.

- Some enterprises lack a sense of social responsibility to participate in vocational education and do not fully recognize the importance of industry-education integration.
- Enterprises lack specialized teacher training teams and training programs, making it difficult to effectively undertake the practical training tasks of “double-qualified” teachers.

Teacher Level: Insufficient Motivation for Career Development

- Some teachers are content with the status quo and lack the initiative and enthusiasm to improve their practical abilities.
- Teachers have limited time and energy to participate in enterprise practice, technological research and development, and other activities, and lack effective incentive mechanisms, making it difficult to form sustained learning motivation.
- The social status and treatment of vocational college teachers are relatively low, making it difficult to attract outstanding enterprise technical talents to join the teacher team.

IV. CASE ANALYSIS

A. A VOCATIONAL AND TECHNICAL COLLEGE IN JIANGSU PROVINCE: “SCHOOL-ENTERPRISE COLLABORATIVE TRAINING + PROJECT-DRIVEN IMPROVEMENT” MODEL

Focusing on equipment manufacturing majors, this vocational and technical college has established an integrated “production, teaching, research, and application” cooperative relationship with 20 leading local enterprises, and constructed a “double-qualified” teacher training model. Its core implementation data and mechanisms are shown in the following table:

TABLE 1. Statistical Table of Core Data of “Double-Qualified” Teacher Training in a Vocational and Technical College in Jiangsu Province

Core Measures	Implementation Details	Quantitative Indicators
Dual Mentor System	Enterprise mentors (technical backbones/executives) + on-campus mentors (famous teachers), one-on-one pairing	Covering 100% of professional teachers, with an average annual guidance time of ≥ 80 class hours
Teacher Practice Workstation	Co-built with 12 enterprises, providing practical positions, technical data, and salary subsidies	Teachers have an average of ≥ 3 months of enterprise practice per year, and the subsidy standard is 80% of the salary of enterprise technical personnel
Joint Project Research Mechanism	Schools and enterprises jointly apply for scientific research projects and technical research projects, and share results	Completed 35 projects at or above the provincial level in the past 3 years, with 12 transformed results
Dynamic Assessment System	Enterprise practice, project results, and practical training guidance effects are included in the assessment, with a weight of $\geq 40\%$	The excellent rate of assessment increased from 32% to 58%

Note: The quantitative indicators in this table are the actual empirical results obtained through three years of tracking and statistics of the school’s “double-qualified” teacher training work, including the actual coverage of the dual mentor system, the actual average enterprise practice

time of teachers, the actual number of provincial-level projects completed, and the actual change in the assessment excellent rate. These data are derived from the school’s annual teacher training work report and the joint statistical data of cooperative enterprises, reflecting the actual effect

of the training model.

search and development”.

1) Implementation Effects

- The proportion of “double-qualified” teachers among professional teachers in the school reaches 82.6%, of which 85% of teachers have more than 3 years of enterprise practice experience;
- Teachers have guided students to win 18 national awards in vocational skills competitions, and the enterprise satisfaction rate with graduates reaches 96.3%;
- Schools and enterprises have jointly developed 42 courses and compiled 28 textbooks, 12 of which have been selected as national planned textbooks, forming a positive interactive cycle of “teaching-practice- re-

B. AN INDUSTRIAL COLLEGE IN GUANGDONG PROVINCE: “SCHOOL-ENTERPRISE CO-CONSTRUCTION AND CO-MANAGEMENT + DUAL-IDENTITY INTERIM APPOINTMENT” MODEL

This industrial college was co-founded by a vocational college and a leading industry enterprise. It implements a governance model of “co-construction, co-management, and sharing” by schools and enterprises, and promotes a “dual-identity interim appointment” mechanism. The effects of teacher mutual appointment and resource sharing are shown in the following table:

TABLE 2. Effect Table of Teacher Mutual Appointment and Resource Sharing in an Industrial College in Guangdong Province

Cooperation Dimension	Specific Content	Implementation Effects
Teacher Mutual Appointment	Enterprises select technical backbones/executives to serve as part-time teachers (accounting for 35% of the total number of teachers); college teachers are appointed as technical consultants of enterprises (accounting for 60% of professional teachers)	Part-time teachers teach an average of ≥ 160 class hours per year, and teachers provide an average of ≥ 200 hours of enterprise services per year
Co-construction of Training System	Schools and enterprises jointly formulate training standards and training programs, and the training teachers are composed of enterprise experts and on-campus famous teachers	Developed 26 “post-course-competition-certificate” integrated courses, 12 of which are included in provincial standards
Resource Sharing Platform	Enterprises open production workshops and R&D centers; colleges provide talent training and technical support	The total value of shared equipment reaches 120 million yuan, and more than 800 enterprise employees are trained annually
Talent Delivery Cooperation	Give priority to delivering graduates to cooperative enterprises, and enterprises participate in the entire process of talent training	More than 2,000 talents have been delivered in the past 5 years, and 60% have become technical backbones of enterprises

C. A SECONDARY VOCATIONAL SCHOOL IN ZHEJIANG PROVINCE: “REGIONAL INDUSTRY CONNECTION + HIERARCHICAL AND CLASSIFIED TRAINING” MODEL

Based on the regional characteristic industries of e-commerce, the school implements differentiated training for

teachers at different levels. Its hierarchical training program and effects are shown in the following table:

TABLE 3. Effect Table of Hierarchical Training of “Double-Qualified” Teachers in a Secondary Vocational School in Zhejiang Province

Teacher Level	Training Focus	Training Methods	Implementation Effects
Young Teachers (under 35 years old)	Practical operation ability + basic teaching skills	1–2 years of on-the-job training in enterprises + mentoring + teaching research	The acquisition rate of “double-qualified” qualifications increased from 30% to 65%
Backbone Teachers (35–50 years old)	Collaborative innovation ability + curriculum construction ability	Enterprise project R&D + “post-course-competition-certificate” curriculum development	Presided over 15 educational reform projects at or above the provincial level and won 3 provincial teaching achievement awards
Famous Teachers (over 50 years old)	Achievement transformation ability + radiation and leading ability	Establishing famous teacher studios + enterprise technical services	Established 5 famous teacher studios, with an annual technical service income of ≥ 3 million yuan

D. CASE ENLIGHTENMENT

Based on different school-running orientations and industrial backgrounds, the three case colleges have formed distinctive “double-qualified” teacher team construction models, but all reflect the core logic of industry-education integration, providing important enlightenment for path optimization:

1) School-Enterprise Collaboration is the Core Driving Force:

It is necessary to establish long-term and stable school-enterprise cooperative relationships, clarify the responsi-

bility and benefit distribution mechanisms of both parties, realize resource sharing and complementary advantages, and form a joint force for talent training;

2) Practice Orientation is the Key Principle:

Teacher training must be closely linked to industrial needs and job requirements, and practical capabilities should be improved through enterprise practice, project R&D, and other methods to avoid “empty talk”;

3) Classified Training is an Effective Strategy:

According to the levels and professional characteristics of

teachers, formulate differentiated training programs to meet the development needs of different teachers and improve the pertinence of training;

4) Mechanism Guarantee is an Important Support:

It is necessary to establish a scientific and reasonable evaluation and incentive mechanism and resource guarantee mechanism, fully mobilize the enthusiasm of teachers and enterprises to participate, and ensure the continuous advancement of construction work.

V. OPTIMIZATION FRAMEWORK OF “DOUBLE-QUALIFIED” TEACHER TEAM CONSTRUCTION PATH FROM THE PERSPECTIVE OF INDUSTRY-EDUCATION INTEGRATION

Based on theoretical analysis, current situation investigation, and case experience, this paper constructs a “four-in-one” path optimization framework (see Figure 1).

A. SPECIFIC OPTIMIZATION STRATEGIES

Institutional Guarantee System: Constructing a Multi-Collaborative Policy Support Mechanism

1) Improving Recognition Standards:

Formulate a unified national recognition standard for “double-qualified” teachers, clarifying core indicators such as theoretical teaching ability, practical operation ability, and industry work experience. Implement a “dynamic certification” system with a review every 3 years to ensure that teachers’ abilities continuously meet the standards.

2) Strengthening Policy Incentives:

Provide policy support such as tax reductions and exemptions, financial subsidies, and priority project application for enterprises participating in the training of “double-qualified” teachers; Incorporate the construction of “double-qualified” teacher teams into the assessment and evaluation system of vocational colleges, link it with enrollment plans and fund allocation, and give special rewards to colleges with outstanding construction results.

3) Innovating Management Systems:

Break through the limitations of teacher establishment and implement an employment system combining “fixed establishment + mobile establishment”; optimize the professional title evaluation system, taking enterprise practice experience, technological R&D results, practical training teaching effects, etc., as core indicators for professional title evaluation, and the weight of practical ability indicators in senior professional title evaluation shall not be less than 40%.

Training Model Innovation: Constructing an Industry-Education Collaborative Capacity Improvement System

1) School-Enterprise Collaborative Training Model:

- Establish school-enterprise joint training bases, requiring teachers to have a cumulative enterprise practice of not less than 6 months every 3 years;
- Schools and enterprises jointly formulate training programs, integrating enterprise production projects and technical research tasks into the training process.

2) Hierarchical and Classified Training Model: Formulate differentiated programs for teachers at different levels:

- Young Teachers: Through “on-the-job practice + teaching research”, arrange 1-2 years of on-the-job training in enterprises, paired with on-campus famous teachers for mentoring;
- Backbone Teachers: Participate in “project R&D + curriculum development”, carry out technical research in cooperation with enterprises, and take the lead in developing “post-course-competition-certificate” integrated courses;
- Famous Teachers: Establish famous teacher studios to carry out “achievement transformation + radiation and leading”, drive the growth of young teachers, and provide technical services for enterprises.

3) Project-Driven Training Model:

- Taking real enterprise projects and industry technical problems as carriers, organize teachers to participate in project R&D, product upgrading, technology promotion, and other activities to improve their ability to solve practical problems in practice;
- Encourage teachers to cooperate with enterprise technical personnel to apply for scientific research projects, and give profit sharing for successfully transformed scientific and technological achievements (the share of the teacher team shall not be less than 50%).

Evaluation Mechanism Reform: Constructing a Scientific and Diversified Assessment and Incentive System

1) Optimizing Evaluation Indicators:

Establish a “trinity” evaluation indicator system of “theoretical teaching + practical teaching + industry contribution” (see Table 4).

2) Diversified Evaluation Subjects:

- Construct an evaluation subject system involving four parties: schools, enterprises, industry associations, and students;
- Schools focus on evaluating teaching ability, enterprises focus on evaluating practical ability and industry adaptability, industry associations focus on evaluating professional and technical level, and students focus on evaluating teaching effects to ensure objective and fair evaluation results.

3) Improving Incentive Mechanisms:

- Establish an incentive system combining “material incentives + spiritual incentives + career development incentives”;
- Directly link evaluation results with performance distribution, professional title promotion, and career development, and give priority to recommending teachers who have been rated excellent for three consecutive years for professional title promotion or middle management positions.

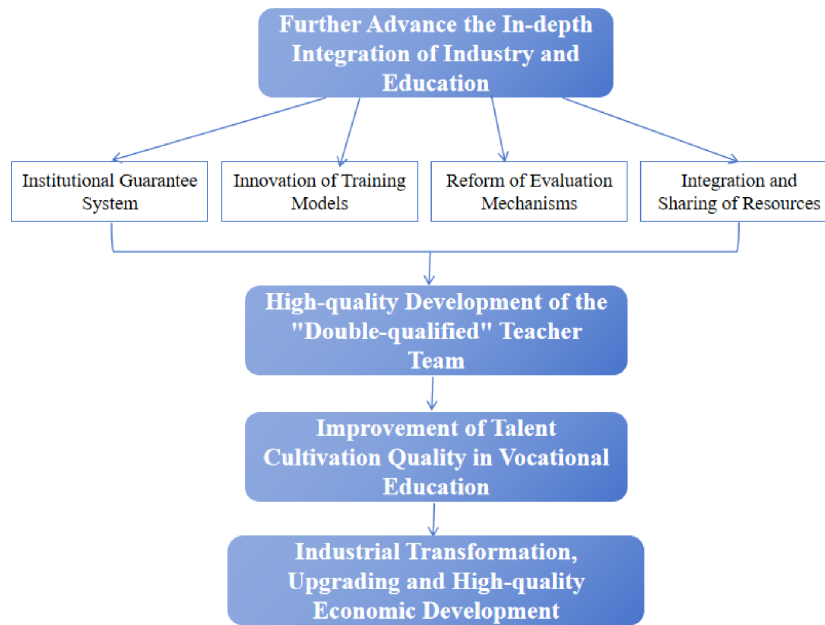


FIGURE 1. Path Optimization Framework

TABLE 4. "Trinity" Evaluation Indicator System for "Double-Qualified" Teachers

First-Level Indicators	Second-Level Indicators	Weight	Evaluation Subjects
Theoretical Teaching Ability	Achievement of teaching objectives	0.08	School, Students
Theoretical Teaching Ability	Innovation of teaching methods	0.07	School, Students
Theoretical Teaching Ability	Timeliness of curriculum content update	0.05	Industry Association, Enterprise
Practical Teaching Ability	Level of practical training operation guidance	0.15	Enterprise, Students
Practical Teaching Ability	Rationality of practical training project design	0.10	Enterprise, School
Practical Teaching Ability	Ability to develop practical teaching resources	0.08	School, Industry Association
Industry Contribution	Enterprise practice experience	0.12	Enterprise, Industry Association
Industry Contribution	Technological R&D and achievement transformation	0.15	Enterprise, Industry Association
Industry Contribution	Industry training and technical services	0.10	Enterprise, Industry Association
Comprehensive Quality	Professional ethics and dedication	0.05	School, Students
Comprehensive Quality	Teamwork and communication skills	0.05	School, Enterprise

VI. EMPIRICAL ANALYSIS: FEASIBILITY AND EFFECTIVENESS VERIFICATION OF PATH OPTIMIZATION

A. DATA SOURCE AND RESEARCH DESIGN

To verify the feasibility and effectiveness of the path optimization strategy, this paper selects 2 majors (Mechanical Design, Manufacturing and Automation, E-commerce) of a vocational and technical college in Jiangsu Province as pilots to implement the above optimization path for a period of 2 years. 40 teachers from the pilot majors are selected as the experimental group, and another 40 teachers with similar conditions are selected as the control group (without implementing the optimization path). Data are collected through questionnaire surveys, interviews, teaching effect evaluation, etc., for comparative analysis.

B. ANALYSIS OF EMPIRICAL RESULTS

Effect of Teachers' Ability Improvement

The improvement range of the experimental group teachers in practical operation ability, curriculum development ability, collaborative innovation ability, etc., is significantly

higher than that of the control group (see Table 5). It should be noted that the optimization path proposed in this paper focuses more on improving teachers' practical operation ability, curriculum development ability, and collaborative innovation ability, which are the core weaknesses of "double-qualified" teachers. For theoretical teaching ability, the experimental group and the control group had a high baseline level before the experiment (the pre-test scores were 7.5 and 7.4 respectively), so the improvement range was relatively small. The conclusion of this paper emphasizes that the optimization path has achieved "significant improvement in key competence dimensions", rather than "significant improvement across all dimensions", which is more in line with the actual experimental results.

TABLE 5. Comparison Table of Teachers' Ability Improvement between the Experimental Group and the Control Group (Unit: Score, Full Score 10 Points)

Ability Dimension	Pre-test Score (Experimental Group)	Post-test Score (Experimental Group)	Pre-test Score (Control Group)	Post-test Score (Control Group)	Difference Range (Percentage Points)
Practical Operation Ability	6.2	8.5	6.3	7.1	21.9
Curriculum Development Ability	5.8	8.1	5.7	6.5	24.6
Collaborative Innovation Ability	5.5	7.9	5.6	6.4	23.4
Theoretical Teaching Ability	7.5	7.8	7.4	7.7	1.3

1) Effect of Teaching Quality Improvement

Indicators such as the passing rate of practical operation skills assessment, the acquisition rate of vocational qualifi-

cation certificates, and employment satisfaction of students in the experimental group are significantly higher than those in the control group (see Table 6).

TABLE 6. Comparison Table of Student Training Quality between the Experimental Group and the Control Group (Unit: %)

Quality Indicators	Experimental Group (n=280)	Control Group (n=275)	Difference Range (Percentage Points)
Passing rate of practical operation skills assessment	92.5	77.2	+15.3
Acquisition rate of vocational qualification certificates	88.3	75.7	+12.6
Employment satisfaction	94.7	84.5	+10.2
Professional counterpart rate	89.6	76.2	+13.4
Enterprise satisfaction	93.2	81.8	+11.4

2) Effect of Deepening School-Enterprise Cooperation

During the pilot period, the depth and breadth of cooperation between the majors of the experimental group and enterprises were significantly expanded:

- Added 18 new school-enterprise cooperation projects, 11 more than the majors of the control group;
- Jointly developed 12 “post-course-competition-certificate” integrated courses, 7 more than the control group;
- Co-built 3 practical training bases, 2 more than the control group;
- The funds invested by enterprises in teacher training reached 1.8 million yuan, an increase of 85% compared with before the pilot.

C. EMPIRICAL CONCLUSIONS

Through 2 years of pilot practice and data comparative analysis, the empirical results show that:

1) The “four-in-one” path optimization framework constructed in this paper has strong feasibility and can effectively solve the prominent problems in the construction of “double-qualified” teacher teams;

2) The optimized path can significantly improve the practical operation ability, curriculum development ability, and collaborative innovation ability of “double-qualified” teachers;

3) The improvement of the quality of the teacher team directly drives the improvement of the quality of vocational education talent training, and the students' practical skills, employment competitiveness, and enterprise satisfaction have been significantly improved;

4) The optimized path can stimulate the enthusiasm of enterprises to participate in industry-education integration, deepen the depth and breadth of school-enterprise cooperation, and realize the coordinated development of education and industry.

VII. CONCLUSION

This paper constructs a “four-in-one” path optimization framework from four dimensions: institutional guarantee, training model, evaluation mechanism, and resource integration. The main research conclusions are as follows:

1) Industry-education integration and the construction of “double-qualified” teacher teams form a bidirectionally interactive and dynamic relationship: industry-education integration provides a practical platform and resource support for the construction of “double-qualified” teacher teams, which is a prerequisite; the construction of “double-qualified” teacher teams provides core talent guarantee for industry-education integration, which is a key support.

2) Institutional guarantee, training model, evaluation mechanism, and resource integration are the four core factors affecting the construction of “double-qualified” teacher teams, which are interrelated and indispensable.

3) Empirical research demonstrates that this optimized path effectively enhances the core capabilities of “double-qualified” teachers, driving significant improvements in technical talent training and the depth of school-enterprise cooperation. Such a framework provides a highly operable and feasible blueprint for vocational institutions to build teaching teams capable of mastering both academic theory and modern industrial practices.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Hunan Vocational College of Engineering, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

AUTHOR CONTRIBUTIONS

Conceptualization – Yu Jia and Yi Li; methodology – Yu Jia and Yi Li; investigation – Yu Jia and Yi Li; writing-original draft preparation – Yu Jia and Yi Li. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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