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DISCUSSION ON THE SCHOOL-ENTERPRISE COOPERATION MODE OF HIGH-LEVEL INTEGRATION OF INTERNET OF THINGS BASED ON THE INTEGRATION OF POSITION, COURSE, COMPETITION AND CERTIFICATE

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Abstract: In the process of professional development, by deepening cooperation between schools and enterprises, clarifying talent cultivation goals, optimizing the professional curriculum system, enhancing course resources, and implementing teaching method reforms, a school-enterprise cooperation model has been established, characterized by 'position-based courses, certification-integrated courses, and competition-driven courses.' This model integrates position, course, competition, and certification, systematically deepening school-enterprise cooperation. It defines the curriculum system from the perspective of the technical chain, integrates the standards of vocational skill level certificates from the perspective of the talent chain, and conducts 'dual-teacher courses' from the perspective of the innovation chain. This article, based on the principle of 'position-based courses, certification-integrated courses, and competition-driven courses,' aims to create an integrated theoretical and practical teaching and training environment, establish methods such as 'triple-teacher training' and 'dual-teacher teaching and evaluation,' thereby enhancing the strength of the teacher team and the quality of student training.
Keywords: Post; Course; Competition and certificate; Integration of course and certificate; Dual-teacher course; Teaching method reform

1 INTRODUCTION

This paper solves the three pain points by deepening the practice of school-enterprise cooperation, clarifying the goal of talent training, professional curriculum system, optimizing curriculum resources and carrying out teaching method reform.

First, how to address the shift in the positioning of secondary vocational education. As the focus of secondary vocational education has shifted from being solely employment-oriented to a balance between employment and further education, students 'multiple choices and diverse growth have become the norm[1]. Data shows that the college entrance rate for Shanghai's secondary vocational students has consistently been close to 100% over the years. Therefore, it is urgent to promptly introduce integrated programs while adjusting the professional talent training plans to align with higher vocational education[2].

Second, how to align with the trends in industrial development. The thriving digital economy continuously generates new application scenarios, and the industry's requirements for professional skills are becoming more sophisticated, multifaceted, and practical[3]. For positions such as testing, implementation, marketing, and after-sales service, which primarily involve graduates from secondary and higher vocational schools, specific application scenarios are essential for their professional success. This necessitates deepening the connection between job roles and courses, and integrating course certification, to cultivate technical and skilled talents who are recognized by enterprises, have a solid theoretical foundation, and possess strong technical skills, as well as professionals with interdisciplinary expertise[4].

The third point is how to innovate the model of course construction. Enterprises that align with the majors of secondary and higher education typically require versatile talents who can master a wide range of professional skills. From the perspective of school talent cultivation, aligning with enterprise standards and enhancing skill training has become the preferred approach for course teaching and practical training.

2 SCHOOL-ENTERPRISE COOPERATION MODE OF MIDDLE AND HIGH SCHOOL INTEGRATION BASED ON THE INTEGRATION OF POSTS, COURSES, COMPETITIONS AND CERTIFICATES

2.1 Refinement of the School-Enterprise Cooperation Mode

In terms of the technical chain, the analysis and decomposition of job-course alignment and school-enterprise cooperation are conducted to clarify the professional capabilities required for five positions in the IoT system integration, IoT technical services, and electronic product application technical services: IoT installation and commissioning technician, sensor network installation and commissioning technician, sensor product tester, sensor product installation and maintenance technician, and intelligent terminal installation and commissioning technician. This approach aims to build a curriculum system that can effectively cultivate students' skills in electrical engineering,

electronics, sensors, IoT, and intelligent terminals. In the talent chain dimension, the integration of courses and certification focuses on three types of vocational skill level certificates: sensor network application development, IoT installation and commissioning, and intelligent hardware installation and commissioning[5]. Collaborating with standard-setting enterprises, we develop corresponding integrated courses, with a particular emphasis on developing sensor network application development into a high-quality course. Based on the logic of skill development, these integrated courses are progressively arranged in independent practical teaching segments over the semester. Through the integration of theoretical and practical learning, students can meet the requirements for vocational skill level and standard assessment[6].

In the innovation chain dimension, the competition and course advancement are integrated. Based on the technical regulations of the IoT technology application and maintenance event from the Shanghai 'Starlight Plan' Vocational College Skills Competition, and incorporating the teaching methods refined during the competition training and intensive training, the teaching and evaluation models have been improved to enhance students 'advanced skills and innovative thinking[7]. With a focus on' dual-teacher courses, 'schools and enterprises collaborate to offer blended online and offline courses, enterprise practice courses, and other educational reforms. This approach combines' participation in teaching 'with' participation in evaluation,' increasing the involvement of enterprise mentors in both classroom instruction and practical training[8].

2.2 Specific Practices

2.2.1 Establishing a business based on production, facing regional economic development planning majors

The Internet of Things (IoT) serves as the infrastructure of the digital economy era, playing a crucial role in promoting the deep integration of the digital and real economies, facilitating industrial transformation and upgrading, and fostering high-quality economic development. The '14th Five-Year Plan' of the country explicitly identifies IoT as one of the seven key industries in the digital economy. The 20th National Congress of the Communist Party of China first included IoT in its report, highlighting the state's strong commitment to the development of the IoT industry.

In Shanghai, the Internet of Things (IoT) industry is a crucial part of the '2+ (3+6) + (4+5)' modern industrial system, specifically in the electronics and information sector. The 14th Five-Year Plan for Shanghai outlines the need to accelerate the large-scale application of smart sensors and expedite the development of the Shanghai Smart Sensor Industry Park. It also outlines plans for the development of the IoT industry and related applications in areas such as smart elderly care, new city construction, and modern agriculture. Special plans released by new cities like Jiading and Songjiang also propose requirements and measures for the development of sensor and IoT industries.

The research on enterprises reveals that over 300 companies in Shanghai have the qualifications to integrate intelligent sensor technology systems. Over 60% of the demand for composite talents with an application electronics technology major and a higher vocational education level or below is expected over the next five years, primarily in roles such as testing of smart electronic products, on-site implementation, marketing, and after-sales service. Students with at least one year of internship experience during their studies have a job opportunity rate exceeding 80%.

To meet the needs of regional economic development, including the construction of Shanghai's modern industrial system, the development of electronic information industry clusters, and the establishment of new city industrial parks, this article outlines how to cultivate technical talents with comprehensive skills through systematic and coherent skill training and knowledge enhancement. These talents will be proficient in designing and manufacturing smart electronic products, developing sensor network applications, and maintaining and applying intelligent hardware systems.

2.2.2 Set courses based on job requirements and based on the analysis of vocational ability

The sensor and IoT industry is characterized by a wide range of technologies, diverse skills, and broad applications. It demands technical and skilled professionals with a broad foundation, versatility, and a focus on development. When designing the curriculum, it is essential to focus on developing students' lifelong learning abilities while also emphasizing the enhancement of specialized skills and cultivating foundational competencies relevant to their future roles. Therefore, schools design their curricula based on occupational fields, breaking down professional competencies into specific components, integrating the characteristics of integrated secondary and higher vocational education, and implementing an integrated design approach.

Identify job positions. Based on enterprise research, identify the positions (groups) where secondary and higher vocational students are concentrated. In conjunction with the specific employment needs of school-enterprise cooperation units (Table 1), determine that the professional fields corresponding to these positions are Internet of Things (IoT) system integration, IoT technical services, and electronic product application technical services. Specifically, IoT system integration includes the position of IoT installation and commissioning technician. IoT technical services include the positions of sensor network installation and commissioning technician, sensor product tester, and sensor product installation and maintenance technician. Electronic product application technical services include the position of intelligent terminal installation and commissioning technician.

Table 1 Professional Corresponding Occupational Fields, Occupations (Positions)

order number	Jobs in the enterprise	occupational area	Occupation (job)
1	Integrator of smart sensor systems	IoT system integration	IoT installation and commissioning officer

2	Intelligent sensor system operation and maintenance personnel	Internet of Things technology services	Sensor network installation and commissioning officer Sensor product tester Sensor product installation and maintenance personnel
3	Intelligent sensor technical support personnel	Electronic product application technology service	Smart terminal installation and debugging operator
4	Pre-sales staff for smart sensor products	/	
5	Smart sensor product salesperson		
6	Sensor network application software developer		

Modularization. Given that students 'abilities typically follow a normal distribution, a small number of underperforming students may not be able to handle positions with specific technical requirements, while a few outstanding students can excel in roles with higher technical demands. When designing the curriculum structure around professional roles, the program has integrated pre-sales, sales, and development positions, which are not explicitly included in the talent cultivation goals. Courses such as IoT application, electronic product automation, application development, and product marketing (Table 2) are offered as restricted electives to develop students' specialized vocational skills.

Table 2 Professional Module Courses

order number	Jobs in the enterprise	Course modules	course title
1	Integrator of smart sensor systems	Internet of Things applications	Internet of Things cabling Internet of Things operating system IoT cloud platform application
2	Intelligent sensor system operation and maintenance personnel		
3	Intelligent sensor technical support personnel	Electronics automation	Electronic product automation assembly Electronic automation testing
4	Pre-sales staff for smart sensor products	product marketing	Customer demand management Electronics marketing
5	Smart sensor product salesperson		
6	Sensor network application software developer	Application development	APP program development C language programming

Optimizing course content through school-enterprise collaboration, developing digital and practical training resources, and integrating enterprise equipment, cases, and processes into the curriculum. For instance, in the collaboration with New Land, the school and enterprise jointly developed practical training resources that include real-world cases from New Land's smart stores, smart municipal services, and smart factories. The co-built training labs include the NEWLAB IoT key technology lab, the IoT typical industry application lab, and the IoT comprehensive application lab. The introduced industrial-grade equipment and platforms include IoT gateways, application development terminals, laser beam modules, various sensors and sensing modules, the full-stack intelligent application system for IoT, and accompanying training manuals. By recreating real-world enterprise development environments, projects, and processes, these resources aim to enhance students' practical skills.

2.2.3 Use certificates to integrate courses and develop courses with skill level certificates

In collaboration with enterprises that have established vocational skill level standards, we aim to jointly develop integrated courses and related resources. Taking the 'Vocational Skill Level Standard for Sensor Network Application Development' as an example, this article outlines how school-enterprise cooperation can be conducted to develop two independently set practical courses, 'Sensor Network Application Development (Beginner)' and 'Sensor Network Application Development (Intermediate)', based on the vocational skill requirements outlined in the standard. To align with the vocational skill level requirements, a comprehensive set of course resources, including lesson plans, courseware, micro-lessons, theoretical question banks, and operational question banks, are developed. These courses are offered in the fifth and seventh semesters of integrated secondary and higher vocational programs, covering both secondary and higher vocational stages. Additionally, single-chip microcomputer and embedded systems courses are introduced at the beginning to facilitate a step-by-step development of students' vocational skills. Table 3 sets the teaching content according to the vocational skill level standard.

Table 3 Teaching Content According to the Vocational Skill Level Standard

Vocational skill level/course name	Occupational skill requirements	Practical course teaching content
Sensor network application development (elementary)	Engaged in inspection and testing, installation and debugging, prototype testing and other work, can build and communicate the equipment bus according to the wiring diagram, complete data	Simulation, digital, switch data acquisition, wired networking communication, short distance wireless communication, low power consumption narrowband networking

	acquisition and other work.	communication.
Sensor network application development (middle rank)	Engaged in coding implementation, function verification, system debugging and other work, able to complete data acquisition, wired communication, wireless communication and other work according to the data manual, development guide, etc.	Sensor technology, wireless sensor network technology, RFID technology, NB-IOT technology, LoRa technology, Internet of Things gateway application technology and Internet of things application development technology.

2.2.4 Promote teaching by competition and refine innovative teaching methods for vocational skills competitions

Drawing on the evaluation criteria from the Shanghai 'Starlight Plan' Vocational College Skills Competition for IoT Technology Application and Maintenance, and in line with enterprise requirements, a 'dual-teacher course' has been established. Teachers are brought into schools to lead the competition training, working alongside enterprise engineers and core teachers, who are Huawei from leading enterprises in the electronic information industry. They refine the competition evaluation standards and innovate teaching methods based on long-term enterprise practice. Enterprises are also involved in teaching by offering practical courses, with 540 class hours of enterprise teachers being stationed at schools each academic year. These courses utilize the practical training rooms and resources co-built through school-enterprise cooperation. Enterprises are also involved in the evaluation process, using an online teaching platform to strengthen enterprise evaluations in integrated theory and practice courses, selecting outstanding students to participate in the competition. Through these three approaches, a 'triple-teacher training' competition training method and a 'dual-teacher teaching and evaluation' practical teaching method have been developed.

3 ACHIEVEMENTS AND EFFECTS

3.1 Promoting Integrated Practice

This civilization sets the goal of talent cultivation: This major is committed to moral and technical development, aiming for students to achieve all-round development in morality, intelligence, physical fitness, aesthetics, and labor. It primarily targets enterprises and institutions in the computer, communication, and other electronic equipment manufacturing sectors, cultivating individuals with high cultural standards and humanistic qualities, who possess solid professional knowledge and skills, and have excellent professional ethics and an innovative spirit. These individuals are capable of engaging in work related to IoT system integration, IoT technical services, and electronic product application services, and are equipped with foundational knowledge for career development, as well as high-quality technical and skilled talents.

3.2 Building Integrated Courses

The course 'Application Development of Sensor Networks' is divided into two parts: 'Application of Sensor Technology' for the secondary vocational stage and 'Application Development of Sensor Networks' for the higher vocational stage, corresponding to the primary and intermediate levels of the Vocational Skills Certificate for Sensor Network Application Development. The course consists of a theoretical component and a practical training component. The course 'Sensor Technology' has been successfully designated as a municipal-level high-quality online open course by higher vocational colleges. The 32-hour primary practical training course for 'Application Development of Sensor Networks' was developed through collective preparation by school-based professional teachers and IoT industry engineers, resulting in 16 lesson plans, 8 courseware, 8 micro-lessons, and 3 question banks, among other teaching resources.

3.3 Cultivating Excellent Talents

Through methods such as 'triple-teacher training' and 'dual-teacher teaching evaluation,' the quality of professional talent cultivation has been significantly improved, and an excellent teaching team has been established. In recent years, 12 textbooks have been edited or co-edited by professional teachers, and 21 papers have been published in important domestic and international journals. They have undertaken 7 municipal-level projects and industry-university-research collaborations, and 2 municipal-level course construction projects. Two teachers have joined master studios, one teacher is a member of the teaching and research group of the municipal secondary vocational school's Internet of Things (IoT) specialty center, and two teachers have participated in international cooperation projects. They have also provided 13 enterprise technical services to society, totaling over 1.79 million yuan. Professional students have won several gold, silver, and bronze awards in the Shanghai regional competition of the China International College Students Innovation and Entrepreneurship Competition; they have won the national second prize in the National College Students Electronic Design Competition. In the 2024 National Vocational Colleges Skills Competition, the selection contest for the secondary vocational group, they won the municipal first prize in' Electronic Product Design and Application' and the national silver prize.

4 EXPERIENCE SUMMARY

The key to the service economy is the integration of industry and education. A consortium of professional and IoT industry associations, IoT enterprises, AI companies, and other electronic information enterprises has been formed to deepen cooperation with leading electronic information companies. This consortium aims to meet the needs of regional economic and industrial development in the area where the main campus is located, accurately define talent cultivation goals, and lay a solid foundation for the establishment and development of these programs.

The core of deepening the integration of enterprises into schools is to introduce key equipment, typical processes, and critical technologies from the current industrial chain into schools through teaching environments, platforms, and resources. It also involves actively engaging enterprises in vocational education, providing students with real-world industry equipment, projects, experiences, and opportunities on campus, ensuring that students acquire the practical skills required by enterprises.

The construction of ideological and political education in courses is the direction. As a sector that embodies the uniqueness of 'hard technology' and the critical importance of addressing 'bottlenecks,' the sensor and IoT industry requires schools to systematically develop case studies and resource libraries that can be integrated into projects, tasks, and teaching. This approach subtly guides students to embrace core socialist values, fostering a sense of patriotism and craftsmanship through their course learning and practical experiences, and nurturing their aspirations to serve the country with their skills.

5 PROMOTION AND APPLICATION

Scope of application: This paper is applicable to the relevant secondary and higher vocational majors related to the Internet of Things, such as the Internet of things technology application and electronic technology application in secondary vocational schools, and the Internet of things application technology and applied electronic technology in higher vocational schools.

Application scenario: The "position-based course, certification-based course, and competition-promoted course" in this paper can be systematically replicated to build a complete professional school-enterprise cooperation model; it can also be applied in different aspects, such as clarifying the professional orientation, building the course system, developing integrated courses, and exploring teaching method reform.

Precautions: The foundation of the school-enterprise cooperation model, which integrates job requirements into courses, certification into courses, and competitions into courses, is to clearly define the industry's requirements for professional skills. This requires thorough research to map out the industrial chain, technology chain, and job clusters, and to identify the specific job needs. The scope of this research is similar to the' Professional Talent Demand Analysis and Forecast Research Report' at the start of a new major, making it particularly suitable for concurrent development when a new major is launched.

6 CONCLUSION AND PROSPECTS

The "integration of positions, courses, competitions, and certification" perspective on the school-enterprise cooperation model is not a simple addition. Instead, it starts with industry needs, focuses on capability development, and ensures comprehensive evaluation. Through deep collaboration between schools and enterprises, it reconstructs the entire talent cultivation process. This model marks a fundamental shift in vocational education from being supply-driven to demand-driven, serving as the "golden key" to cultivating high-quality technical and skilled talents for future industrial development. To achieve this model, it requires the government, schools, enterprises, and industries to break down barriers, innovate boldly, and jointly build a new ecosystem of industry-education integration.

Specifically, the school-enterprise cooperation model based on 'job-course-competition-certificate integration' is an inevitable choice for building a high-quality vocational education system. The future development directions include: First, greater intelligence: AI and big data technologies will be deeply integrated into personalized learning path planning, skill deficiency diagnosis, virtual simulation training, and precise employment recommendations. Second, a more ecological approach: it is necessary to form an educational ecosystem where government, schools, enterprises, industry organizations, and research institutions collaborate and co-prosper. At the same time, it will be more international: by introducing advanced international occupational standards, course resources, and competition systems, it aims to cultivate technical and skilled talents with an international perspective. Finally, it will be more lifelong: providing flexible and open lifelong learning and skill enhancement channels for different groups, including students, enterprise employees, and social individuals, based on the integration of 'job-course-competition-certificate'.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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