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Enhancing Engineering Competencies through Industry-Education Integration: Evidence from an Industrial Internet Talent Cultivation in Chinese Application-Oriented Undergraduate University

Yanan Qian[1]*, Wai Yie Leong[2], Chengrui Chen[1], Jianli Yang[1]
[1]Chongqing Institute of Engineering, Chongqing 400056, China
[2]INTI International University, Nilai 71800, Negeri Sembilan, Malaysia

**Author to whom correspondence should be addressed.*

Abstract

As a result of the integration of new information technologies and manufacturing, the Industrial Internet has raised new requirements for applied talent cultivation. This study, based on Chongqing Institute of Technology, explores practical pathways under the industry-education integration model. Through school-enterprise collaboration, the talent training plan was revised, courses like "Industrial Internet Technology" and "Industrial APP Development" were added, and enterprise cases were integrated into teaching. Co-built laboratories introduced enterprise-used equipment and supported innovation through secondary development. In the past two years, leading to the completion of five equipment upgrade projects based on enterprise feedback. Practical teaching capabilities were enhanced via teacher enterprise rotations and dual-qualified training. Students' hands-on abilities were strengthened through certificate-integrated courses and project-based practices, improving the high-quality employment rate to 32% and provincial-level competition awards to 17%. However, challenges remain in interdisciplinary skill development, deeper integration of professional and specialized education, and rapid iteration of teaching resources. Future efforts should focus on optimizing curricula and building dynamic adjustment mechanisms to meet technological evolution. This study offers practical insights for Industrial Internet talent development in application-oriented undergraduate universities.

Keywords

Industrial internet; Application-oriented undergraduate university; Talent cultivation; Industry-education integration

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1. Introduction

In November 2012, General Electric of the United States first proposed the concept of the Industrial Internet [1]. In 2017, in the "Guiding opinions on deepening the development of "Internet + advanced manufacturing" and Industrial Internet," China first proposed the concept of Industrial Internet. According to the definition of the China Alliance of Industrial Internet, "Industrial Internet" is a new type of infrastructure and application model formed by the deep integration of new-generation information and communication technologies with advanced manufacturing. By achieving comprehensive interconnection of people, machines, and things, it builds an intelligent network system covering the entire industrial chain and value chain, supporting the digitalization, networking and intelligent transformation of manufacturing [2]. From 2018 to 2025, the State Council of the People's Republic of China has included the content of the Industrial Internet in the government work report for eight consecutive years [3]. According to the "China Industrial Internet Industry Economic Development Report (2024)" released by the China Academy of Industrial Internet in December 2024, the core industrial internet industry added value scale reached 1.53 trillion Chinese Yuan in 2024 [4].

Industrial Internet talents are individuals who not only master the knowledge and skills of next-generation information and communication technologies but also possess specialized expertise in industrial fields, enabling them to engage in and contribute to Industrial Internet-related work [5,6]. Industrial Internet talents are an important resource for developing the Industrial Internet and achieving the digitalization, networking, and intelligent transformation of the real economy. The core goal of application-oriented undergraduate universities in cultivating industrial internet talents is to train engineers who can solve problems directly in industrial sites, rather than pure theoretical researchers.

There are many problems in talent cultivation as follows:

(1) Insufficient resources for talent cultivation: Although some universities have initiated teaching reforms, due to the shortage of teachers and incompletion of the curriculum system, the quality of cultivation is difficult to meet the needs of the industry [7].

(2) Incomplete cultivation system: The demand for Industrial Internet talents appears to have multi-level characteristics, where both academic talents are needed to drive technological innovation, and application-oriented talents are required to solve engineering problems [8]. Due to insufficient depth of industry-education integration and delayed transmission of enterprise demands, the training directions have become disconnected from industry development [9].

(3) Disjoint between iteration of teaching resources and development of industrial technology: Industrial Internet teaching relies on industrial-grade equipment such as PLCs and industrial gateways, as well as digital twin systems.

However, these devices have rapid technological updates and high purchase costs, making it difficult for educational institutions to continuously update them. This study explores practical pathways for cultivating Industrial Internet engineers through deep school-enterprise integration.

2. Methodology

Industry-education integration model aims to break down the barriers between schools and enterprises and achieve a deep integration of educational resources and industrial resources [10,11]. This research establishes cooperative relationships with well-known enterprises in the industry, jointly exploring the cultivation paths for application-oriented talents in Industrial Internet, especially carrying out in-depth cooperation in the formulation of talent cultivation plans, course development, and practical teaching. Enterprises participate in the teaching process and provide engineering project cases and practical opportunities, while schools provide professional talents for enterprises, achieving mutual benefit and win-win results for both parties.

2.1. Formulation of specialty talent cultivation plans

Based on the analysis of industrial demands and the school-enterprise collaboration mechanism, this study has structurally reorganized the specialty talent cultivation plans for the Industrial Internet. A systematic investigation was conducted into the job competency requirements of over 20 enterprises related to the Industrial Internet and intelligent manufacturing. Combined with the engineering education accreditation standards, a three-dimensional training system centered on "industrial system integration capability" was established: the technical dimension (professional skills such as industrial data collection and industrial networks), the engineering dimension (practical abilities such as system design, debugging, and operation maintenance), and the vocational dimension (soft skills such as engineering ethics and sustainable development awareness).

In the design of the curriculum system, the "platform + module" architecture was adopted: the specialty foundation platform integrated interdisciplinary courses such as "Industrial Control Basics" and "Industrial Network "; the specialty direction modules were set based on the typical engineering job requirements of Industrial Internet in the field of intelligent manufacturing (such as industrial control system integration engineers, intelligent production line operation and maintenance engineers), and included core courses such as "Industrial Internet Technology" and "Intelligent Manufacturing System Modeling and Simulation", as well as practical content such as digital twin and industrial robot programming.

2.2. Co-construction laboratories by school and enterprises

The school and the enterprise established a technical committee to design the construction plan of the laboratory jointly, which was designed based on the "teaching, learning, doing, research, and innovation" integrated concept [14]. The laboratories imported the mainstream equipment from the enterprise's current production lines (such as FANUC, ABB industrial robots, Siemens, Mitsubishi, Omron, etc., mainstream manufacturers' PLCs), aiming to ensure that the experimental equipment maintains technical synchronization with the enterprise's current equipment as much as possible. In addition, retained secondary development interfaces to support teachers and students in conducting equipment function expansion and craft innovation.

The laboratories were also embedded with real enterprise projects (such as an assembly production line of direct-acting limit switch and a secondary sedimentation tank cleaning robot for sewage treatment), and a dual-mentor team (enterprise engineers and school lecturers) was formed to carry out project-based teaching, achieving the advanced cultivation of capabilities from equipment operation to system integration. In the past two years, it has supported teachers and students to complete 5 equipment renovation and process optimization projects to support the enterprise's production.

2.3. Construction of teaching staff

The teaching staff is the key to talent cultivation. To enhance the professional quality and practical ability of teachers, various measures have been taken. For instance, teachers are selected to participate in industry training, such as going to cooperative enterprises for job rotation to learn advanced experience in intelligent manufacturing and Industrial Internet talent cultivation, as well as project implementation methods; teachers are also sent to participate in training courses organized by enterprises, such as "Industrial Internet Application Technology" skills training courses. Enterprise experts are invited to the school to give lectures and provide guidance on teaching, enabling teachers to understand the latest industry trends and actual demands of enterprises.

2.4. Certification of leading enterprises

To enhance students' practical abilities, this research organizes students to participate in enterprise training and qualification certifications. By attending cutting-edge industry technology training, such as fully leveraging the "Collaborative Education Project of Industry-University Cooperation " of the Chinese Ministry of Education and sending teachers and students to Tianjin to participate in the "Niagara Application Technology Training" organized by Honeywell. Those who pass the assessment can obtain the "Niagara N4 IoT Certification." At the same time, this research actively promotes the integration of courses and certifications. The assessment of the "Industrial Robots and Applications" course is integrated into the FANUC robot certification training. Those who pass the examination can obtain the "FANUC Robot Debugging Engineer (C-level)" certificate authorized by FANUC. This has achieved precise alignment between teaching content and industry technical standards, enabling students' robot debugging capabilities to meet the job requirements of enterprises directly. Moreover, obtaining authoritative certification not only enhances students' competitiveness but also urges the teaching team to update practical teaching content.

2.5. Construction of engineering teaching cases

Case-based teaching is a pedagogical approach that is student-centered; through the description of a real event or case in a specific business scenario, students propose solutions based on their own reading, research, thinking, and discuss under the guidance of the teacher, which is particularly applicable in the theoretical teaching process of application-oriented undergraduates [12,13]. The case library used in this study collects many actual cases from enterprises, covering the application of the Industrial Internet in different industries, and has the characteristic of representativeness and practicality. Through the analysis and discussion of the cases, students can understand the actual application scenarios of the Industrial Internet and the methods for solving problems. In the specific implementation process, the teacher simplifies or modularizes the actual engineering cases of enterprises and designs special teaching for students, integrating the teaching content into various teaching activities.

3. Results and discussion

3.1. Outcomes of talent cultivation

After three years of talent cultivation and teaching implementation by Industry-Education Integration, remarkable achievements have been made. As shown in **Figure 1**, from 2022 to 2025, the number of courses with teaching cases increased from 0 to 12, the total number of cases rose from 0 to 30, and enterprise projects grew from 0 to 10. This demonstrates steady progress in case construction and enterprise cooperation, which provides a solid foundation for application-oriented talent cultivation. **Figure 2** presents the outcomes of student cultivation between 2022 to 2025. The high-quality employment rate rose from 8% to 32%, the award rate in provincial-level and above competitions increased from 5% to 17%, and the industry certification rate improved from 0% to 32%. These results suggest significant enhancement of students' professional competence, practical ability, and employability. In **Figure 3**, student satisfaction with teaching increased from 82% in 2022 to 92% in 2025, while employer satisfaction with talent cultivation rose from 73% to 90%. This reflects the high recognition of teaching reforms and the school-enterprise collaborative model by both students and enterprises.

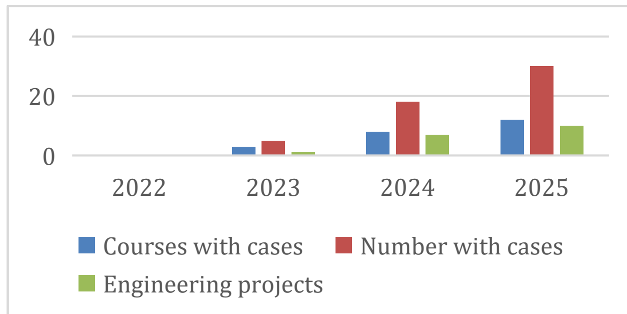

Figure 1. Achievements in teaching case and enterprise project construction.

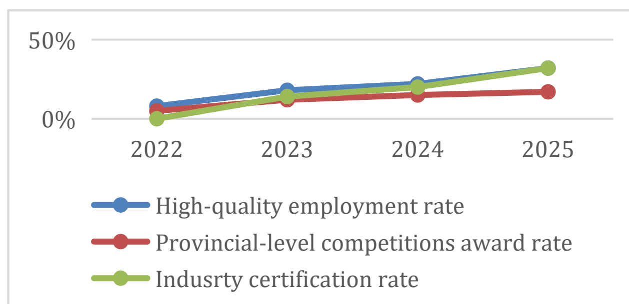

Figure 2. Key student performance metrics.

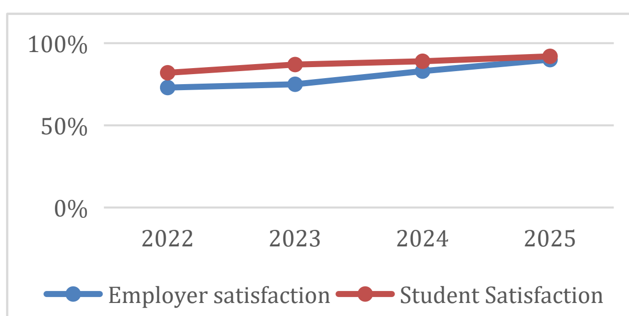

Figure 3. Student and employer satisfaction with talent cultivation.

To ensure the reliability of these outcomes, employment rates and course construction data were obtained from the official annual statistics of the school. Competition results were validated against provincial and national records. Student and enterprise satisfaction data were collected through structured annual questionnaires, with a response rate exceeding 85%, and were crosschecked with enterprise feedback reports. These measures helped to enhance the accuracy and credibility of the reported findings.

3.2. Discussion

The findings are consistent with Qian et al. (2023) and Chen et al. (2022), who emphasized the importance of application-oriented talents cultivation in Industrial Internet. In this case, engineering thinking was strengthened by linking multiple courses through projects that required both technical and problem-solving. At the same time, the challenge of resource iteration noted by Liu *et al.* was partly confirmed [15]. Industrial Internet education depends on rapidly evolving industrial equipment and platforms that are costly to update. While joint laboratories and enterprise resource sharing alleviated some constraints, timely upgrades remain difficult, reflecting the structural barriers faced by application-oriented universities.

4. Conclusion

This study demonstrates that industry-education integration significantly improved case-based teaching, enterprise projects, and student outcomes, including employment, competition awards, and industry certification. These achievements can be attributed to the systematic embedding of industrial cases, the expansion of industry-education collaboration, and the alignment of curricula with certification standards, which together enhanced students' competence and employability. But this is a single-institution case, and the data are based on institutional statistics and surveys, which may involve subjectivity. Future research should adopt multi-institutional, longitudinal approaches with broader datasets to strengthen generalizability.

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Disclosure statement

The authors declare no conflict of interest.

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