Journal of International Education and Development
2025, VOL. 9, NO. 10, 261-264
DOI: 10.47297/wspiedWSP2516-250060.20250910

Research on Teaching Reform of Internet of Things Majors in Universities under the Background of Emerging Engineering Education

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ABSTRACT

The construction of Emerging Engineering Education aims to cultivate innovative and interdisciplinary engineering talents capable of adapting to industrial upgrading. As a key technology supporting the digital economy and intelligent manufacturing, the Internet of Things (IoT) is widely used in fields like smart cities and industrial internet, leading to a continuously growing demand for professionals. However, current IoT education in domestic universities faces problems such as rigid teaching models, weak practical components, and insufficient faculty expertise, making it difficult to meet the requirements of Emerging Engineering Education and industrial needs. Based on an analysis of the current situation and drawing on theories including Constructivism, Outcome-Based Education (OBE), Conceive-Design-Implement-Operate (CDIO), and the integration of industry and education, this paper proposes a systematic reform framework guided by the core principles of demand orientation, practice priority, and collaborative advancement. The reform focuses on three aspects: teaching models, practical systems, and faculty development. It aims to promote the transformation of IoT education from knowledge impartation to competency cultivation, thereby enhancing the industry relevance and innovative practical abilities of cultivated talents.

KEYWORDS

Emerging engineering education; Internet of things; Teaching reform; Integration of industry and education

1 Introduction

With the ongoing advancement of Emerging Engineering Education [1], cultivating innovative and interdisciplinary engineering talents suited to industrial transformation has become a crucial task for higher engineering education [2]. IoT technology, serving as a core support for the digital economy and intelligent manufacturing, finds extensive application in areas such as smart cities [3] and the industrial internet [4], creating an increasingly urgent demand for specialized professionals. Nevertheless, current IoT teaching in universities still confronts numerous challenges, including traditional teaching methods, a disconnect between practical content and industry needs, and a lack of interdisciplinary knowledge and practical experience among faculty, all of which constrain the improvement of talent cultivation quality [5-6]. Existing research often focuses on isolated improvements, such as curriculum optimization or university-enterprise cooperation, lacking a comprehensive reform framework [7-8]. Therefore, through literature review and logical analysis, this paper starts by identifying core problems, integrates educational theories and industrial demands, and systematically constructs a path for IoT teaching reform, intending to provide references for program construction and teaching optimization in similar institutions.

2 Current problems in iot teaching at universities

2.1 Inflexible teaching model, insufficient alignment with competency cultivation

LoT majors require a balance between theoretical understanding and practical application. However, current teaching remains predominantly teacher-centered, relying on lectures and PPT presentations. Classroom interaction often stays at a superficial level of simple Q&A, lacking activities that guide students to conduct self-directed inquiry around real-world IoT projects. Consequently, students struggle to translate theoretical knowledge into practical thinking. Furthermore, the evaluation system over-relies on final written exams and homework assignments, emphasizing the memorization of theories like sensor principles and communication protocols. It lacks a combined quantitative and qualitative assessment standard for core competencies such as project development capability, problem-solving skills, and teamwork, failing to comprehensively reflect the quality of talent cultivation.

2.2 Weak practical teaching, significant disconnect from industry needs

On one hand, practical components lack systematic design: course experiments are often basic, "follow-the-steps" verification exercises, disconnected from comprehensive and innovative practices, making it difficult for students to form a coherent logic for IoT system development. On the other hand, university-enterprise cooperation often remains at a "superficial collaboration" stage—involving activities like company visits and short-term internships. Enterprises do not deeply participate in practical course design or training project development. Some collaborations even see "no substantive interaction after signing agreements" due to a lack of long-term mechanisms. This results in a significant gap between the practical content students encounter and the actual technological applications in the industry.

2.3 Shortcomings in faculty competency, insufficient momentum for reform support

Regarding knowledge structure, some teachers come from single disciplinary backgrounds like computer science or electronic engineering and lack deep mastery of the cross-disciplinary knowledge involved in the entire IoT chain ("perception-network-application"), making it difficult for them to competently teach interdisciplinary courses. In terms of practical experience, most teachers follow an "academia-to-academia" career path, having not participated in enterprise IoT project development. Their understanding of technological iterations and job competency requirements within the industry is limited. Consequently, they find it challenging to provide industry-relevant guidance when supervising student practice, thereby constraining teaching quality improvement.

3 Theoretical basis and core principles for reform

3.1 Theoretical basis

Constructivism emphasizes that knowledge must be actively constructed by learners rather than passively received. This theory provides a core direction for designing teaching activities in IoT majors. By creating authentic learning scenarios and guiding students to autonomously explore project details, students can develop a deep understanding of IoT technology through participation, rather than merely memorizing theoretical knowledge.

Outcome-Based Education (OBE) theory starts from the ultimate goal of talent cultivation and drives the optimization of teaching content and evaluation systems backwards. In IoT major reform, the core competency requirements of the industry for talents can first be clarified, followed by adjustments to curriculum setup, teaching methods, and assessment standards accordingly. This ensures the entire teaching process revolves around "cultivating talents that meet demands," avoiding a disconnect between teaching and objectives.

The Conceive-Design-Implement-Operate (CDIO) framework focuses on the holistic cultivation process in engineering education, covering the four key phases of Conceive, Design, Implement, and Operate. This aligns well with the core requirement of "system development" in IoT majors. Based on this concept, practical teaching can run through the entire talent cultivation process, allowing students to start from project conception and progressively complete design, development, and actual operation, thereby comprehensively enhancing their engineering practice abilities.

The Integration of Industry and Education theory advocates for the deep integration of educational and industrial resources, providing theoretical support for collaborative education between universities and enterprises in IoT majors. Guided by this theory, enterprises can be promoted to deeply participate in teaching processes, integrating real industrial needs and technical standards into courses and practices, breaking down the barriers between university teaching and industrial reality, and achieving seamless connection between talent cultivation and job requirements.

3.2 Core principles

The Demand Orientation principle requires that the entire reform process revolves around the competency requirements of the industry for IoT talents. It is necessary to first clarify the specific needs of the industry in areas such as IoT system design, device debugging, and data processing, then translate these needs into teaching objectives, and subsequently adjust course content, practical projects, and evaluation methods to ensure the cultivated talents can directly meet job requirements.

The Practice Priority principle emphasizes strengthening the core role of practical teaching in talent cultivation. The technical nature of IoT majors determines that practical ability is a key literacy for talents. Therefore, the reform must increase the proportion of practical teaching, optimize the design of practical links, and allow students to accumulate experience through more hands-on operation, avoiding "armchair strategizing" and effectively enhancing hands-on skills and problem-solving abilities.

The Collaborative Advancement principle requires that the reform directions of the teaching model, practical system, and faculty development remain consistent. These three aspects must coordinate and support each other—innovations in the teaching model rely on the practical system to provide implementation scenarios, optimization of the practical system depends on the faculty team to provide professional guidance, and faculty development needs to enhance capabilities based on the reform requirements of the former two. This avoids the effect of reforms in one area being negated by shortcomings in others, thereby forming a synergistic force for reform.

4 Specific paths for teaching reform

4.1 Innovation in teaching models

In terms of teaching methods, a combined model of project-based teaching and blended teaching is adopted, supplemented by virtual simulation tools. Specifically, project-based teaching uses typical application scenarios of the Internet of Things such as intelligent agricultural monitoring and smart home control as teaching projects, allowing students to complete the entire process from requirement analysis, scheme design to code implementation and system testing in groups, thereby cultivating students' engineering practical abilities. Blended teaching releases micro-lesson videos, technical documents, and other learning materials through an online teaching platform, enabling students to independently study basic theoretical knowledge; the offline class time is mainly used for project discussions, scheme optimization, and practical guidance, thereby improving teaching efficiency. Virtual simulation tools are used to simulate experimental conditions with limitations such as large-scale IoT equipment networking and complex scene deployment, allowing students to repeatedly practice key skills such as device configuration and protocol debugging in a virtual environment.

In terms of teaching evaluation, a diversified assessment system oriented towards practical ability is established. Specifically, the following aspects are included in the assessment scope: the quality of project completion (40%), experimental operation performance (20%), and team collaboration and process performance (20%). The weight of the final written test score is accordingly reduced to 20%. The project evaluation focuses on the completeness of system functions, the rationality of technical solutions, and the quality of technical documents; the practical operation focuses on assessing students' hands-on abilities such as equipment configuration and fault diagnosis; the process performance is examined through group mutual evaluation and teacher observation, to assess students' team collaboration and problem-solving abilities. This evaluation method can comprehensively reflect students' comprehensive abilities in knowledge application, engineering practice, and team collaboration.

4.2 Optimization of the practical system

To systematically enhance students' engineering practice and innovation capabilities, this research has constructed a three-level progressive practical system of "basic experiments-comprehensive design-innovative practice", as shown in Figure 1. This system first lays a solid foundation for students' core skills in the basic experiment stage through standardized experiments such as sensor data collection and communication protocol configuration; then it transitions to the comprehensive design stage, requiring students to form project groups and integrate knowledge from multiple courses to complete comprehensive designs such as intelligent environmental monitoring systems, in order to cultivate their system integration and teamwork abilities; finally, in the innovative practice stage, students are encouraged to independently choose topics, combining AIoT and industrial interconnection and other industry frontiers to carry out innovative projects or participate in academic competitions, fully stimulating their innovative potential and ability to solve complex engineering problems.

To ensure that the practical content is in line with the development of the industry, this research emphasizes integrating industrial resources into each practical stage through deep school-enterprise cooperation. The school will jointly build a practice base with leading enterprises in the Internet of Things field, introducing real enterprise project cases into the comprehensive design and innovative practice stages, allowing students to directly face the technical demands and standards of the industry front line; at the same time, an enterprise mentor database will be established, inviting senior technicians to participate in practical guidance, project evaluation, and technical lectures, forming a collaborative mechanism of "industry demand driving practical content, enterprise experts participating in the training process", thereby effectively breaking the barriers between universities and industries and significantly improving the industry-applicability and practicality of talent cultivation.

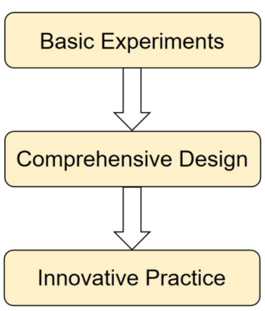

Figure 1 Practical system

4.3 Faculty team building

Address the issues of teachers' lack of interdisciplinary ability and engineering experience by regularly organizing teachers to participate in cross-disciplinary training related to IoT, covering areas intersecting with IoT like artificial intelligence and cloud computing, to help teachers improve their knowledge structure and adapt to interdisciplinary teaching needs. Simultaneously, arrange for teachers to enter enterprises and participate in actual project development, accumulating engineering practical experience and understanding the direction of industrial technology iteration to avoid lagging teaching content.

Furthermore, supplement faculty strength through talent introduction and external appointments: prioritize the introduction of "dual-qualified" teachers with work experience in IoT enterprises—teachers who can both deliver theoretical knowledge and guide practical operations. Also, appoint senior industry experts as part-time teachers to regularly participate in course teaching, practical guidance, or specialized lectures, bringing industry perspectives and experience to students and compensating for the lack of engineering practical experience among in-house faculty.

5 Conclusion

Under the background of Emerging Engineering Education, the teaching reform for IoT majors in domestic universities needs to be centered on the core logic of collaboratively advancing the "teaching model, practical system, and faculty team." Innovation in the teaching model, through the implementation of project-based and blended learning coupled with competency-oriented evaluation, provides methodological support for talent competency cultivation. Optimization of the practical system, by constructing a three-tier "basic-comprehensive-innovative" chain and deepening university-enterprise collaboration, builds industry-relevant scenarios for skill enhancement. Faculty team building, through cross-disciplinary training, enterprise practice, and the introduction of dual-qualified talents, provides quality assurance for the implementation of reforms. The synergy of these three aspects can precisely address key current teaching issues such as "insufficient interaction, disconnection of practice, and faculty shortcomings," ultimately enhancing the quality of IoT talent cultivation. This will ensure that the output talents better meet the industry's demand for those who "understand technology, can practice, and are good at innovation," aligning with the Emerging Engineering Education construction requirements of "interdisciplinary integration, practical innovation."

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