Education Insights

Article

Research on the Reform of the "Internet of Things Control Technology" Course Teaching Based on Project-Based Teaching

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Abstract: "Internet of Things Control Technology" is a core course in the Internet of Things Engineering major, with both multidisciplinary intersection and engineering practice. In response to the problems of disconnection between theory and practice and insufficient development of students' innovative capabilities in current teaching, this study introduces a project-based teaching method, which divides the course into three stages: consolidating basic knowledge, participating in project practice, and project assessment. Through typical teaching projects, it drives theoretical learning, and strengthens practical training in combination with real enterprise cases, and builds a teaching model of "projects as the main line, students as the main body, and teachers as the guide". Practice shows that the reform has effectively improved students' independent learning ability and engineering application ability, and provided a reference for the reform of engineering course teaching.

Keywords: project-based teaching; IoT control technology; teaching reform; practical ability; engineering literacy

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1. Introduction

"Internet of Things Control Technology" is a core-specific elective course for the undergraduate major of IoT engineering. It has multi-disciplinary intersection and strong engineering practice. Its knowledge system integrates advanced mathematics, control theory, communication technology and other fields, requiring students to have the practical ability to transform theory into IoT control system design while mastering the classic control principles. The course is based on advanced mathematics, circuit analysis, etc., and connects follow-up courses such as sensor technology, wireless communication technology, and undertakes important tasks in cultivating students' control engineering thinking and system design capabilities. However, as the core course of emerging cutting-edge disciplines, current teaching still faces significant challenges: the traditional teaching model focuses on basic theoretical derivation, and the experimental links are mostly based on verification simulations (such as Matlab algorithm verification), and the lack of comprehensive project training throughout the complete engineering process, making it difficult for students to establish the relationship between subject knowledge and actual engineering problems, and the cultivation of practical ability and innovative thinking lags. In addition, the differences between the multi-disciplinary complexity of the course content and the students' independent learning ability also have a direct impact on the teaching effect, and it is urgent to explore teaching reform paths that fit the characteristics of the course.

The project-based teaching method takes "project as the main line, teachers as the guide, and students as the main body", emphasizing the deep integration of theoretical learning and practical application through real projects, and its core concept of "learning by doing" is highly consistent with the engineering attributes of "Internet of Things Control Technology". Many scholars have tried project-based teaching methods, Zhang explores the impact of project-based learning (PBL) on student learning effectiveness [1]. The research uses meta-analysis methods to convert 66 experimental or quasi-experimental research papers based on PBL in the past 20 years into 190 effect values, and conduct in-depth quantitative analysis from sample size, mean and standard deviation. The results show that compared with the traditional teaching model, PBL significantly improves students' learning outcomes and has a positive effect on academic performance, emotional attitudes and thinking skills. Maros explores the effectiveness of project-based learning in economics teaching through experiments [2]. In Slovak Middle School, 123 students were divided into control group and experimental group. The same teacher taught on the same topic within the same time. The control group adopted traditional teaching and the experimental group adopted project-based learning. Then, students' knowledge was measured in the same way, and the comparison results were compared with the parameter two-sample t test, which proved that the project-based learning efficiency was higher. Fan's research found that the development of the electronics industry has changed the needs of career roles and skills, and students from China University of Electronic Science and Technology complain that the theory of electronic engineering courses is separated from industry needs [3]. To this end, the school introduces innovative courses based on project learning to cultivate students' professional and technical skills. The article details two PBL projects. After 40 students' evaluation, the innovative course significantly improves student satisfaction. 65% of students prefer this interdisciplinary PBL course than traditional courses, reflecting its innovative effects of practical teaching. Rehman focuses on changing students' attitudes towards math learning with the help of project-based learning [4]. The article points out that in recent years, students have decreased their interest in mathematics learning and have not realized its importance and value. The study adopted a set of pre-post-test research designs, allowing 25 students to complete complex project tasks based on mathematical learning materials and their own areas of interest. During the project creation process, a formative technical environment was created. The results show that project-based learning enables students to form positive cognition of mathematics, stimulates learning motivation and sense of responsibility, cultivates self-confidence, design thinking, and promotes innovation, proving that project-based learning helps shape students' positive attitude towards mathematics learning. Dai studied how to effectively train IoT engineers with both hard and soft skills. The teaching framework is constructed based on activity theory and project-based learning, and applied to the Internet of Things courses of a university in central China [5]. The first half of the course adopts traditional teaching, and the second half is based on new framework teaching, forming a control group and an experimental group. Through questionnaire surveys on students' learning participation and satisfaction, the framework effect is analyzed from dimensions such as teaching models and other dimensions with the help of an intelligent teaching analysis platform. The results show that the new framework can significantly improve students' learning participation and satisfaction, optimize classroom structure, promote the transformation of teaching models, and create a more harmonious classroom atmosphere.

This study introduces project-based teaching into the reform of IoT control technology curriculum, and builds a three-stage teaching system of "consolidating basic knowledge-participating in project practice-project assessment": In the basic knowledge stage, typical and inspiring teaching projects are used to disassemble theoretical knowledge points, and promote independent learning by building a curriculum resource library; introduces real cases of enterprises in the practical stage, and cultivates students' system design and engineering implementation capabilities through simulated project research and development and field internships; builds a dynamic evaluation system covering solution design, practical process and summary reflection in the assessment stage, and strengthens process-based ability orientation. Through this reform, we aim to break through the separation of theoretical and practical problems of traditional teaching, guide students to build a knowledge system in the process of solving practical engineering problems, improve their ability to practice independently, teamwork and innovatively, and provide a replicable practical paradigm for the reform of curriculum teaching in emerging engineering majors.

2. Problems with Current Teaching Methods

2.1. The Theory and Practice Are Out of Touch, and the Cultivation of Engineering Literacy Is Insufficient

Under the long-term leadership of the traditional teaching model, curriculum design always builds a knowledge system with textbooks as the core, especially the explanation of classic control theory. Teachers often devote a lot of teaching energy to the in-depth analysis of formula derivation and theoretical frameworks. For example, in the course of automatic control principals, teachers will spend weeks deriving theoretical formulas such as Laplace transformation and root trajectory. Although students can master the derivation process of these formulas and can also use simulation tools such as Matlab to complete simple control system simulation experiments, once they face the actual Internet of Things engineering scenarios, it is difficult to transform the learned theories into effective methods to solve problems. In the construction of intelligent agricultural greenhouse environmental monitoring and control systems, students need to comprehensively use temperature and humidity sensor data collection, fuzzy control algorithms to adjust ventilation and irrigation equipment and other knowledge. However, due to the lack of teaching cases in actual scenarios, students often fall into the dilemma of inability to combine theory and practice, and it is difficult to design a control system that meets actual needs.

As a key link between theory and practice, the experimental link also has obvious flaws. Most of the current experimental content is mainly verification. Taking Matlab simulation demonstration as an example, students only need to enter preset parameters and instructions according to the steps of the textbook or experimental instruction to easily obtain results that are consistent with the theory. This lack of challenging experimental design makes it impossible for students to experience the complete control system design process. From requirements analysis, solution design, hardware selection to software programming and debugging, students need to think independently and practice independently. Without comprehensive project training, it is difficult for students to cultivate the systematic thinking and innovation capabilities required for engineering practice. In the future practical work, it is often difficult to be competent when facing complex engineering problems such as real-time regulation of industrial automation production lines and optimization of smart city traffic signals.

2.2. Students Lack Subjective Status and Lack Motivation for Independent Learning

The course system of the Internet of Things Engineering major is huge and complex. Not only are there many pre-study courses, it involves multiple fields such as mathematics, electronic circuits, computer programming, etc., but also has high theoretical knowledge, such as digital signal processing, machine learning algorithms, etc., which makes many students feel afraid of difficulties during the learning process. In traditional classrooms, the one-way teaching model of "teacher teaching and student reception" still occupies the mainstream, and classroom interaction is limited to simple questions and answers, lacking in-depth discussion and communication. Teachers promote teaching according to the established teaching syllabus and progress. Students can only passively listen and record, and cannot actively participate in the process of knowledge construction. For example, in the data structure course, teachers mainly explain theories and algorithms, and students rarely have the opportunity to explore and understand the application of data structures through actual programming projects, making it difficult to form a sense of independent learning.

In addition, there are significant differences in students' student source foundation. Some students have a solid foundation in programming and mathematics before entering school, while others need to spend more time understanding the basic knowledge. However, the unified teaching progress and teaching content cannot meet the personalized needs of students at different levels. For students with a good foundation in learning, the regular teaching content and progress are not challenging and it is difficult to stimulate their enthusiasm for learning; while students with weak foundations gradually lose confidence and interest in learning because they cannot keep up with the pace. This "one-size-fits-all" teaching method seriously hinders the stimulation of students' motivation to learn independently, leads to a decrease in students' enthusiasm for learning, and the overall learning effect is also affected. Some students cannot even meet the basic requirements of professional training.

2.3. The Assessment Method Is Single, and Process Evaluation Is Missing

The existing teaching assessment system is mainly based on the written test of the final period, supplemented by daily homework and experimental reports. This assessment model is excessively focused on the examination of knowledge memory, and ignores the comprehensive evaluation of students' comprehensive abilities. The types of questions in the final written test are mostly multiple-choice questions, fill-in-the-blank questions, calculation questions, etc., which mainly test students' memory and simple application of concepts and formulas. It is difficult to effectively test whether students truly understand the connotation of knowledge and whether they can apply knowledge to practical problems. For example, in the assessment of the introduction course of the Internet of Things course, students may get high scores in the written test by memorizing the content of the textbook, but they lack practical application capabilities such as IoT system architecture design and equipment networking.

In actual teaching, ability to design project plan, team collaboration, problem solving, etc. is an important indicator for measuring students' comprehensive quality, but in the existing assessment system, these key abilities lack effective assessment methods. Due to the lack of process evaluation, teachers cannot fully understand students' performance in the learning process, including dynamic changes in knowledge mastery, improvement of practical operation ability, and contributions in teamwork. For example, in the Internet of Things project practice course, students' creative conception, team division of labor and collaboration, problem-solving ability and other performance in the project development process is difficult to fully reflect in the existing assessment. This single assessment method cannot accurately reflect students' learning results, nor can it effectively guide students to pay attention to the learning process, leading to students' misconception that "focus on exam results and neglect the cultivation of ability" and tends to temporarily recite knowledge at the end of the period, while ignoring the cultivation of practical ability and comprehensive literacy, which is not conducive to students' long-term development and the improvement of professional ability.

3. Reform Content Based on Project-Based Teaching

3.1. Teaching Model Reconstruction: Three-Stage Project-Driven System

This study introduces project-based teaching to reform the IoT control technology curriculum and establishes a three-stage teaching system that "merges basic knowledge — participation in project practice — project evaluation" with a structural schematic as shown in Figure 1.

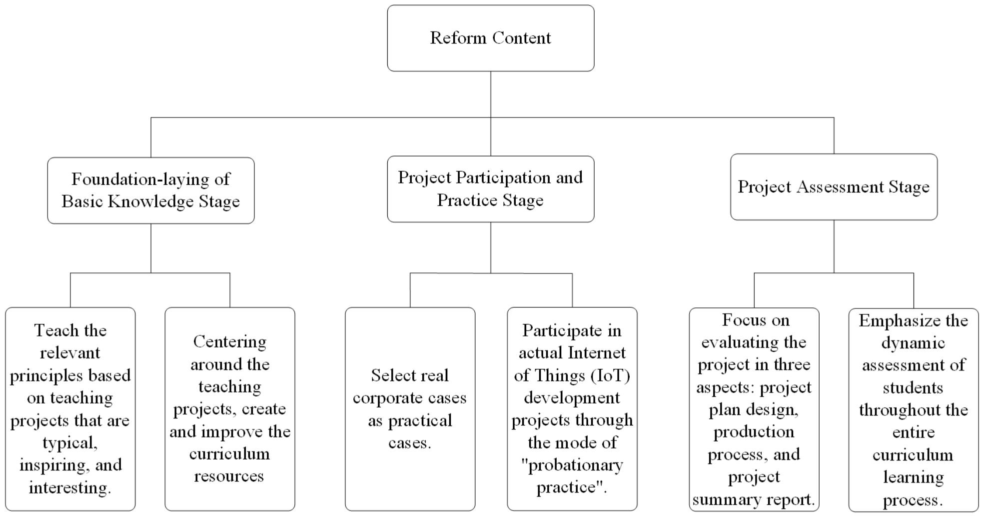

Figure 1. Structural Schematic of Reform Content.

3.1.1. Strengthen the Basic Knowledge Stage: Project-Oriented Theoretical Construction

In the stage of consolidating basic knowledge, teaching projects are designed with the core principles of "typicality, inspiration and fun", which deeply meets the needs of the Internet of Things engineering major. For example, the "Intelligent Temperature and Humidity Control System Design" project naturally integrates control principles such as PID algorithms and system stability analysis into it. Teachers no longer use one-way "principal indoctrination", but dismantle the project into multiple modules such as demand analysis, hardware selection, and algorithm implementation, guiding students to actively think about the theoretical logic behind each link. When explaining the transfer function, combined with the process of sensors collecting temperature and humidity signals in the project and converting them into electrical signals, it helps students understand how mathematical models accurately map actual physical systems, so that abstract theoretical knowledge is closely connected with concrete engineering scenarios, and achieve the "problem solving" knowledge acquisition.

At the same time, a complete supporting curriculum resource library provides strong support for teaching. In the resource library, multimedia courseware presents core knowledge points in the form of pictures and texts, micro-course videos provide fragmented explanations of key and difficult contents, the case library contains actual cases in many fields such as smart home and industrial automation, and the test library covers questions at different levels such as basic consolidation and ability improvement. With the help of the "Super Star Learning" platform, students can preview project background materials before class, watch operation demonstration videos, and have a preliminary understanding of knowledge in advance; in class, teachers focus on questions in students' preview, organize in-depth discussions and difficult analysis, and effectively solve the contradiction of "less learning time and more content". This teaching model prompts students to change from passive acceptance to active exploration, truly realizing the transformation from "teaching-oriented" to "learning-oriented", stimulating students' motivation and enthusiasm for independent learning, and laying a solid foundation for subsequent practical learning.

3.1.2. Participate in Project Practice Stage: Layered and Progressive Engineering Training

1) Simulation project: Group collaborates on comprehensive design

In the simulation project stage, a variety of real cases of enterprises are introduced, including previous excellent graduation designs, industrial Internet of Things monitoring systems, etc., to provide students with practical scenarios that are close to actual projects. The students are divided into groups of 3-5 people. Each group simulates the complete project development process, from demand analysis, solution design, to simulation verification, debugging and optimization, so that students can master all aspects of project development in practice.

Taking the case of "intelligent warehousing and logistics control system" as an example, in the demand analysis stage, students need to conduct in-depth research on the actual needs of cargo storage, handling, sorting, etc. in warehousing management, and clarify the system functional goals; when designing the plan, comprehensively use sensor technology, wireless communication technology and control algorithms to formulate the overall system architecture; in the simulation verification process, Matlab is used to simulate algorithm simulation, simulate core functions such as cargo scheduling and path planning, and optimize algorithm performance through parameter adjustments; finally, combined with the Internet of Things development platform Arduino, to build a hardware prototype to realize sensor data acquisition, equipment control and other functions. During the project implementation process, the team members must perform their duties and be responsible for hardware design, software development, algorithm optimization, etc., and cultivate system integration capabilities through close collaboration. At the same time, teachers regularly organize group reports to guide students to exchange experiences with each other, promptly solve problems encountered in the project, and help students gradually improve their engineering practice abilities.

2) Practical internship: Connecting with real corporate projects

During the practical internship session, establish in-depth cooperative relationships with IoT companies to provide students with opportunities to participate in actual development projects. Students enter the company as "trainees" and personally participate in the real project development process to understand important engineering elements such as project cycle, cost control, and quality standards.

For example, in the debugging project of a factory equipment status monitoring system, students, under the guidance of enterprise engineers, go deep into the factory production line to collect vibration, temperature and other data on equipment operation. Faced with a complex industrial site environment, students need to learn how to optimize sensor layout plans to ensure the accuracy of data collection; during the system debugging process, anti-interference measures are studied and implemented to improve the stability of the system in response to electromagnetic interference and signal attenuation during the operation of the equipment. At the same time, students also need to participate in project progress management, understand project cost accounting methods, and understand how to control development costs while ensuring quality. By participating in real-life projects of the enterprise, students can not only apply the knowledge they have learned to reality, but also get exposed to the industry's cutting-edge technologies and engineering specifications, and cultivate the sensitivity of engineering problems and the ability to solve complex problems. In addition, the practical experience of the company also helps students understand the industry development trends and corporate employment needs, and prepare for future career development. Through the layered practice model of "On-school simulation-Enterprise Practical Practice", students have achieved gradual advancement from theoretical knowledge to engineering practice, and their engineering practice ability has been significantly improved.

3.1.3. Project Assessment Stage: Multi-Dimensional Dynamic Evaluation System

Establish an assessment model that combines "process evaluation + result evaluation" to conduct comprehensive and objective evaluation of students from multiple dimensions to accurately reflect students' learning results and comprehensive abilities.

In the design dimension, focus on examining the rationality of demand analysis, innovative theoretical application and feasibility of technical routes. Teachers form an evaluation team composed of professional teachers and enterprise engineers, and evaluate through project defense, plan reports, etc. For example, in the "Intelligent Building Energy

Management System" project, the review team will evaluate whether students accurately grasp the energy consumption needs of building lighting, air conditioning and other equipment, whether they innovatively use fuzzy control theory to optimize energy distribution strategies, and the operability of technical solutions in actual projects. For demand analysis, detailed scoring rules are formulated and scored from the aspects of demand research methods, demand document integrity, etc.; for the innovative theoretical application, plus points are set to encourage students to break through traditional methods and use emerging technologies to solve problems.

The evaluation of the production process dimension focuses on team collaboration efficiency, problem solving capabilities and engineering specification compliance. Teachers collect evaluation data by observing project progress in real time and participating in group discussions. For example, during the implementation of the "Intelligent Warehousing and Logistics Control System" project, the division of labor and collaboration between team members in hardware assembly and software programming are recorded, and whether the team can quickly locate the problem and propose solutions when encountering problems such as sensor data transmission delays. At the same time, in accordance with industry standards and school experimental specifications, students should check whether they comply with engineering specifications in circuit welding, code writing and other operations. The method of combining group mutual evaluation and teacher evaluation is adopted. Group members score each other based on their contribution, while teachers give comprehensive evaluations based on observations and project logs to comprehensively consider students' practical abilities.

The summary report dimension mainly assesses the quality of technical document writing, ability to summarize results, and awareness of reflection and improvement. Students are required to submit a complete project report covering requirements analysis, design process, test results and other content. Teachers score based on the logic of the document, the accuracy of professional terms, and the standardization of the charts. At the same time, they pay attention to students' refinement and summary of project results, and whether they clearly explain the project's innovation points and practical application value. For example, students need to analyze the achievement of system performance indicators in the report, reflect on the shortcomings in algorithm optimization, hardware selection and other links, and propose improvement directions. In this way, students' summary and induction ability and critical thinking are cultivated.

Dynamic assessment runs through the entire teaching process. In the basic knowledge stage, the "Super Star Learning" platform uses the "Super Star Learning" platform to record students' online learning time, number of course resource views, quality of homework submissions, etc., and conduct a comprehensive evaluation based on the speech quality and participation in classroom discussions; in the practical stage, a project schedule is formulated, each node task is clarified, and the project completion degree is quantitatively assessed. Through this multi-dimensional dynamic evaluation system, students can effectively avoid "pre-exam surprises", guide students to pay attention to the accumulation of abilities in the learning process, promote students' comprehensive development, and also provide a strong basis for the continuous improvement of teaching quality.

3.2. Reform Goals and Breakthroughs in Key Issues

3.2.1. Reform Objectives

Building a teaching model with "project as the main line, students as the main body, and teachers as the guide" aims to break the one-way indoctrination model of "teachers speak and students listen" in traditional teaching. By carefully designing teaching projects that fit the actual situation of IoT engineering, theoretical knowledge is integrated into the process of solving practical problems, and students are inspired to actively explore knowledge. For example, in the intelligent traffic signal control system project, students actively study control algorithms to optimize the efficiency of intersection traffic, and change passive learning to active knowledge.

Create an integrated practical environment of "theory-simulation-practical" through different levels of practice such as on-campus simulation projects and enterprise real projects, allowing students to use simulation tools to verify algorithms after theoretical study, and then enter the enterprise to participate in actual combat, and transform knowledge into the ability to solve complex engineering problems. For example, in the development of industrial Internet of Things monitoring systems, students first simulate data acquisition and analysis through Matlab simulation, and then debug real equipment in the enterprise environment to achieve a deep integration of theory and practice.

Form a replicable project-based teaching paradigm, and by summarizing teaching experience, optimizing curriculum resources, and standardizing teaching processes, a set of standardized plans including project design, teaching implementation, assessment and evaluation are refined, providing practical experience that can be learned from similar curriculum reforms and promoting the overall innovation of teaching models.

3.2.2. Key Issues Solved

In view of students' basic differences, differentiated teaching achieves precise teaching by decomposing projects into "must-do tasks" and "expanding tasks". Must-do tasks ensure that all students master core knowledge and skills. For example, in the smart home control system project, basic sensor data collection and device control are essential content; expansion tasks are aimed at students with strong capabilities, such as introducing artificial intelligence algorithms to achieve intelligent linkage of home devices. At the same time, relying on the online platform to analyze student learning data, students with weak basics push directional animation explanations and basic exercise analysis and other resources, and open cutting-edge technology cases such as edge computing and 5G Internet of Things for students with strong abilities to meet the learning needs of students at different levels.

In terms of precise group assessment, a combination of "inter-group mutual evaluation + teacher evaluation + enterprise review" is adopted. The group mutual evaluation is carried out through an anonymous scoring mechanism, allowing members to evaluate their peers from the perspectives of rationality of division of labor, contribution, communication efficiency, etc. based on the "Team Collaboration Capability Score Table". Teachers give professional evaluations based on the full-process project observation and acceptance of results; corporate engineers comment from the perspective of industry standards and practical applications. For example, in the intelligent warehousing and logistics system project, the three-party evaluation jointly determines the final results of the group members, effectively avoiding the "free ride" phenomenon, and promoting students to actively exert their personal value in team collaboration.

4. Conclusions

This study has achieved remarkable results in project-based teaching reform for the "Internet of Things Control Technology" course. In the process of reform, the limitations of traditional theoretical classrooms were broken and the courses were carefully built into a high-quality practical platform for "doing while learning, learning while doing", effectively and effectively improving students' engineering practice ability and innovative thinking. By consolidating basic knowledge, participating in project practice, and project assessment, theoretical knowledge and practical operations are closely linked, and deep integration is achieved. At the same time, a diversified evaluation and personalized training mechanism has been established to comprehensively and objectively evaluate students' learning results to meet the learning needs of different students.

Looking ahead, subsequent reform work can further expand the depth of school-enterprise cooperation, actively introduce cutting-edge technology projects in the industry, and allow students to get exposed to the most advanced technologies and concepts. We must also vigorously improve the construction of virtual simulation experiment platforms, provide students with a richer and more realistic practical environment, and promote seamless connection between courses and industry needs. The successful practice of this project-based teaching in the "Internet of Things Control Technology" course provides a new idea for engineering curriculum reform. In the future, it can be promoted and applied in other courses in the Internet of Things engineering major, such as sensor technology and wireless communication technology, to form a professional course group driven by "project chain", comprehensively improve the quality of talent training as a whole, and provide more high-quality professional talents to the industry.

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