Teaching Reform and Practice Based on Project-Driven Integration of Microcontroller and Sensor Principle Courses

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Abstract: Microcontroller and sensor principle courses are two core professional courses commonly offered by the Internet of Things engineering in colleges and universities, which constitute an important part of the professional knowledge system of the Internet of Things engineering. However, in the actual teaching process of the two courses, there are problems such as emphasis on theoretical teaching, lack of practical application, fragmentation of content, lack of contact with each other, etc., resulting in poor teaching effect of the two courses and making it unable to truly achieve the purpose of comprehensive ability cultivation. In response to these problems, this paper proposes a teaching reform idea based on project-driven integration of microcontroller and sensor principle courses. Starting from the construction of course integration system, we should optimize course content, perfect the evaluation system, integrate corporate elements, explore the optimization and integration of microcontroller and sensor knowledge, and cultivate students' comprehensive application ability through project-based practical teaching, which carries great significance for improving personnel training quality and creating "first-class applied university".

Keywords: microcontroller; sensor principle; project-driven; course integration; Internet of Things

1. Introduction

In the 21st century, the rapid development of information technology has triggered rapid development of the Internet of Things technology and industry, leading to the huge challenge in the development of the Internet of Things technology in terms of talent quantity and quality. As the main body of talent cultivation, colleges and universities shoulder the heavy responsibility of talent cultivation. To train qualified Internet of Things professionals, many domestic universities have set up Internet of Things engineering major, continually promote the construction and development of Internet of Things and related majors and courses, and actively explore innovative Internet of Things talent training models, course settings and practical teaching systems. In this way, training quality of Internet of Things professionals continues to improve [1]. However, there are still some problems that require in-depth reform and innovation, such as slow update of course content, lack of a systematic knowledge system, lack of characteristics in curriculum settings, and emphasis on theory over practice, which affects the healthy development of the Internet of Things to a certain extent [1-3]. This paper starts from the practical problems in the teaching of the two courses of "Microcontroller and Sensor" in the Internet of Things major, proposes the teaching ideas and teaching modes for the optimization and integration of the "two courses", and proposes a specific implementation route in view of integration and reform of the "two courses" in the teaching of the Internet of Things.

2. Existing Problems

The development of the Internet of Things is inseparable from microcontroller control and sensor technology. Microcontroller is embedded in the perception layer of the Internet of Things and organically combined with the sensor to achieve intelligent control of the objective world information collection. Microcontroller and sensor technology constitute an important part of the professional knowledge system of Internet of Things engineering. They are two important basic professional courses in the professional course system of Internet of Things engineering in colleges and universities, which are also two very important professional skills required to be proficiently mastered by Internet of Things engineering college students. The two courses are highly comprehensive and practical, which play a pivotal role in the course system as an important entry point for cultivating technical application-oriented talents [2,3]. However, seen from the perspective of teaching, microcontroller and sensor are two separate courses lacking of contact with each other, with separate content, monotonous teaching mode, and disconnected content from practice. This makes students have low interest in learning and lack of learning motivation, who are prone to dullness in learning, leading to poor teaching effects and failure to truly cultivate students' comprehensive abilities [1-4]. In response to these problems, reforming teaching ideas and innovating talent training models carry great significance for effectively

improving the teaching quality of the Internet of Things engineering major and enhancing the overall student quality.

3. Teaching Integration-based Reform Ideas

The teaching idea of integrated teaching of microcontroller and sensor principle courses is to optimize theory integration, deeply integrate theory and practice, adopt a project-based teaching mode in practical teaching and introduce corporate elements. That is, starting from the reform of the training program, construct the integrated teaching system and course standards for microcontroller and sensor principle courses, implement moderate and adequate theoretical teaching, take project-based practical teaching, organically integrate microcontroller and sensor in the content and form through project design and implementation, thereby effectively improving teaching quality of the two courses.

4. Integrated Teaching Implementation Plan

4.1. Break through Traditional Cognition and Update Educational Concepts

The school's teaching management department, class teachers and students should break through the traditional education and learning concepts, establish an open concept regarding education and education recipient, and take the initiative to initiate course and teaching reforms [1]. Under the current education system, the school management department (the Academic Affairs Office) should first break through traditional cognition, pioneer and innovate, and boldly implement teaching reforms to promote teaching quality improvement under the principle of conforming to the laws of undergraduate education and teaching. There is need to innovatively revise the teaching management system, optimize the existing teaching quality evaluation system, encourage teachers to innovate traditional classroom teaching models, adopt flexible and diverse teaching methods not limited to one type to improve teaching quality and proficiency [4,5]. Class teachers should identify the problems and deficiencies in the actual teaching process, and take the initiative to think of ways and measures to quickly adapt to the new changes and requirements of the teaching process. For the project-based integrated teaching of microcontroller and sensor, teachers must first actively improve their professional skills, and learn to cultivate the management and overall planning capabilities and technical research methods needed for project-based teaching. Teachers in charge of course reform should fully communicate and exchange, so that the two courses can be taught with complete integration, achieving the effect of one plus one greater than two. Students should actively adapt to the new course content and teaching methods under teachers' guidance. For students with difficulties under challenges, teachers should actively communicate and direct them, help them in learning and communicate with them in thought. In short, course teaching integration should be comprehensively promoted from the three aspects of "teaching, management, and learning".

4.2. Innovate and Optimize Talent Training Programs

Talent training plan refers to normative documents for the school to organize teaching activities and arrange teaching tasks. As the basic basis for the implementation of talent training and quality evaluation, it includes the training objectives and training standards of related professional teaching, course settings, class hour arrangement, etc. [6]. To implement project-based integrated teaching of microcontroller and sensor courses, the training program must be first optimized. Take the Internet of Things engineering major in our college as an example. The original microcontroller and sensor principle course were set up in different semesters. After the talent training plan revision, adjustments are made so that the two courses are arranged in the same semester. This is a prerequisite for integrated teaching. To achieve effective integration, the focus is to optimize and adjust the course content. In view of the characteristics of the Internet of Things engineering, based on the principle of "sufficient practicality", the content of the two courses of microcontroller and sensor are re-integrated and optimized, so that non-essential content are reduced, essential contents are retained and supplemented. Optimization and integration are also made in class hour allocation. In the past, each course had 64 class hours (including 12 experimental hours), and practical class hours took up a small proportion. After the teaching content optimization, the total hours remain unchanged, the theoretical hours are compressed, and the practical hours are increased accordingly, so that the practical hours of the two teaching parts reach 24 hours. In terms of teaching form, courses of the two teaching parts can be taught in two ways. First, microcontroller and sensor are still taught as two courses, the theoretical part and basic experiment courses are taught by two teachers respectively, and the project practice courses are given in a unified manner. Second, the two courses are taught as one course with a teacher to teach the theoretical part, and the experimental courses and project practice are implemented in a unified manner. This is an important form of integrated teaching. In addition, on the basis of teaching integration, the teaching evaluation systems of the two courses should also be integrated with each other. Students should pass the theoretical and practical joint assessment of the two parts on the premise of receiving the entire teaching of the two courses and designing a project to obtain corresponding academic achievements.

4.3. Project-based Teaching Practice

Project-based teaching is an important part of the integrated teaching of microcontroller and sensor principle courses. On the basis of completing the basic teaching content of the two courses, combine microcontroller technology and sensor technology to build a project case of microcontroller + sensor for information collection and signal control, and combine practical applications to strengthen students'

understanding and knowledge of basic principles and applications of microcontroller and sensor, thereby improving students' operational ability and knowledge application ability.

4.3.1. Project design

Project-based teaching content is divided into two parts: project practice and course design.

Project practice is to construct a simple microcontroller control system with microcontroller and sensor after the theoretical basic teaching. The system mainly uses microcontroller to control a single sensor to realize single signal acquisition and display, train students' initial understanding towards the combination of microcontroller and sensor and develop their ability to construct simple Internet of Things system, thereby laying the foundation for the further design of complex Internet of Things systems.

Course design is a practical teaching link and also a key part of project-based teaching. This stage reflects the full integration of the principles of microcontroller and sensor, which constitutes an important link in improving students' comprehensive ability. The process of course design is project-driven. The so-called project-driven is a teaching method. First, it means driving students' learning through project tasks, and guiding teaching through projects; second, it means to achieve the purpose of "learning by doing" through completion of projects, use project as the carrier of knowledge and skills intended for students [7].

In the course design stage, students are required to complete a complete topic. The start of the course design needs to go through research, topic selection, topic defense, etc. Research topic selection is an important part of the course design, which is to conduct overall evaluation and analysis on feasibility of the selected topic, research goal, research content, conceive research methods and technical routes. The opening defense should cover the purpose and meaning of the project, schedule, material budget, and expected goals. Opening defense can help students find problems in project design, correct them in time, and avoid blindness at start [8].

Regarding the project topic, the teacher gives a certain number of reference topics, and students can choose the given topic or extend it by themselves. Of course, the project topic should cover the important knowledge points of microcontroller and sensor as much as possible, and combine the two [2]. For example, if the reference topic for students is "Smoke alarm design based on microcontroller", students may extend it to "Design of home environment monitoring system based on microcontroller" on the basis of this topic. Compared with the reference topic, students add temperature and humidity sensors, light sensor. This method helps to increase students' enthusiasm, autonomy and creativity.

4.3.2. Project teaching method

Starting from the actual project application, a project can be decomposed into several steps to progressively illustrate the software and hardware structure principles and various functional applications of the 51 microcontroller and the corresponding sensor step by step. In this method, the 51 microcontroller programming in high-level programming C language is used to control sensor information collection and processing [4,7].

The setting items are all from simple to complex, corresponding to each knowledge point, so that students gradually master the design method of the information acquisition and control system combining microcontroller and sensor step by step. Through project exercises, by combining simulation design and physical system design, students will see the simulation effect from the simulation phenomenon, and then build the physical experimental device according to the simulation model. In this way, students know what to do, and then consider how to do it. In this way, instruct students to complete tasks step by step, understand and master each knowledge point, and finally integrate hardware simulation capabilities, sensor application capabilities, and comprehensive programming capabilities.

Simple projects and course design projects are designed for this topic. Table 1 shows 5 referable practical course design projects. For simple projects, such as LED display, temperature measurement, etc., the teacher explains the basic tasks, design ideas, and implementation methods of the project, and then the students discuss and actually operate, implement functions of the project according to the implementation plan of the project, thereby deepening the understanding towards working principle and practical application of microcontroller and sensor. These projects all have clear schemes and relatively low difficulty, which mainly cultivate students' basic ability to design the Internet of Things system combining microcontroller and sensor. For the course design project, the teacher proposes the project task, while the project topic selection, topic analysis, plan design, and implementation process are all completed by the students. In the process of project implementation, teachers only play a guiding role. Through project design and practice, complete the comprehensive training of microcontroller and sensor from theory to practice, thus cultivating students' comprehensive hands-on ability [7-9].

Table 1. Allocation table of practical project contents

Project name	Content distribution	
	Microcontroller Technology	Sensor Technology
Temperature monitoring system	Minimal system; LCD1602 liquid crystal display circuit; serial port; programming; PROTUES simulation; circuit board production	Temperature sensor working principle; temperature sensor device DS18B20; temperature signal display processing
Rotation speed measurement system	minimum system, LCD1602 liquid crystal display circuit, keyboard circuit, motor drive circuit, programming, PROTUES simulation, circuit board production	Hall sensor working principle; Hall sensor device UGN3144 module
True and false coin recognition system	Minimal system, LCD1602 liquid crystal display module; A/D conversion; buzzer warning module; programming; PROTUES simulation; circuit board production	Pressure sensor working principle; pressure sensor device XJC-D02-105
Intelligent obstacle avoidance car	Minimal system; LCD1602 liquid crystal display circuit; motor drive module; buzzer warning module; interrupt system; button circuit; programming; PROTUES simulation; circuit board production	Ultrasonic sensor working principle; ultrasonic sensor HC-SR04
IoT environment detection system	Minimal system; serial port communication; A/D conversion; key circuit; programming; PROTUES simulation; circuit board production	Temperature and humidity sensor working principle and temperature and humidity device DHT11; light intensity sensor and device TEMT6000; PM2.5 sensor working principle and device DSM501A

4.4. Project Enterpriseization

To cultivate students' engineering practice ability, through the teaching practice of "industry-university cooperation, collaborative education", the project development model and process of Beijing Sugon are introduced. The course design close to actual scenario is carried out according to the enterprise process, mainly including personnel assignment and job responsibilities, project process documentation, project process supervision, etc. Referring to the development process of Sugon project, rational simplification is made based on the actual situation of the school and students. A complete project team has the basic roles of project leader, hardware developer, software developer, and tester. We divide students into groups of 4-6, and assign each student with different role according to his or her ability. The entire project is divided into stages of conceptual composition, development and design, and work testing. Each stage requires corresponding standardized documents for quality assurance [1,4]. For example, in the project development stage, students are required to output detailed work design documents, work test description documents, etc. Through project documentation coupled with activities like regular project team meetings, students have exercised their communication and cooperation skills, and have also consolidated their professional knowledge in microcontroller and sensor courses.

4.5. Innovative Course Assessment and Evaluation System

Course assessment is a comprehensive evaluation of students' knowledge, skills, and qualities. The assessment is to integrate students' knowledge mastery, skill proficiency, innovation ability, learning attitude, team spirit, etc. into the assessment content [9]. For the integrated teaching of microcontroller and sensor courses, a combination of procedural assessment and summative assessment should be adopted in the assessment, which takes process assessment as the mainstay and summative assessment as the supplement. Process assessment is to assess students' learning status from different focuses based on learning requirements and goals during the course design stage of the project, such as attendance rate, learning attitude, programming ability, system debugging ability, collaboration ability, etc. The summative assessment mainly assesses the theoretical foundation knowledge points. After the course is completed, the final assessment result will be given based on the two stages' results. In the course assessment and evaluation, the project course design link accounts for 40% of the whole course [1]. After completing the project design, students need make a final defense and demonstrate their work. The teacher will rate the project based on completeness in students' work and defense. Excellent works will be used as display items for college exhibitions, or will be recommended for various design competitions and innovation and entrepreneurship competitions, so that students will gain a sense of accomplishment throughout the process.

4.6. Evaluation of Teaching Effect

By integrating the knowledge content of microcontroller and sensor in project-based teaching, it gets rid of the traditional monotonous teaching method, and meets the training requirements of applied talents. Through the integration and linkage of the theoretical knowledge of the two courses, plus specific case application combining microcontroller and sensor, theory and practice are effectively integrated, students' enthusiasm in learning is higher, their desire to study and explore is inspired, and their practical ability is cultivated. Also, education and teaching methods are enriched. Moreover, this teaching method is also able to evaluate students from many aspects, not only assessing students' theoretical knowledge, attendance, and learning attitude, but also assessing students' hands-on practical ability and collaboration ability, so that an objective evaluation of students' comprehensive learning is possible [9].

5. Conclusion

The project-based integrated teaching of microcontroller and sensor principle courses represents an innovative teaching concept under the project-driven teaching mode, and truly gives full play to the teaching idea of taking students as the main body of learning. The purpose of the course reform in this model is to actively explore industry-university cooperation and collaborative education training methods suitable for application-oriented talents, actively adapt to the new situation of "mass entrepreneurship and innovation", meet the deep-level reform and practice requirements of the Internet of Things engineering professional course. The reform helps to improve the teaching quality of microcontroller and sensor principle courses, comprehensively improve students' overall quality, further stimulate students' enthusiasm and creativity in learning, so that talents cultivated by the Internet of Things engineering better cater to the needs of local regional economic development.

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