

Exploration and Practice of Project-Based Teaching Reform Oriented to Engineering Education

-- Take The Wireless Sensor Networks Course as an Example

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Abstract: With the shortening of knowledge iteration cycle, enterprises urgently need innovative practitioners to solve complex engineering problems, and engineering education reform is imminent. Taking the wireless sensor network course of Guangdong University of Science and Technology as an example, this paper explores the related elements of project-based teaching based on real social engineering projects, and constructs a project-based teaching mode with project as the carrier, learning as the center, and engineering quality training as the core. It is hoped to provide reference for quality goals, knowledge deconstruction, implementation process and evaluation system for the transformation of new engineering and the promotion of engineering education.

Keywords: Engineering Education; Project-based Teaching; Exploration Practice.

1. Introduction

With the continuous innovation of the technical and application models of various industries, the differences between the skills and the skills required by students' knowledge and practice have continued to increase, and the traditional education model has gradually become unable to cope with the needs of complex positions. Especially in the field of engineering, new technologies and methods are constantly developing. Students must master the actual application ability in order to adapt to future career development. To this end, the reform of engineering education has become the focus of attention from major colleges and universities in recent years, and the reform of engineering education is imminent.

Solving the problem of complex engineering is the core element of engineering education. Under the background of the new engineering, undergraduate graduates are required to have engineering literacy, integrate the knowledge learned to form high -level project thinking, and solve complex engineering problems. Especially in engineering practice, students need active practice and hands -on ability, and simple theoretical teaching cannot meet their needs. Project teaching, as a teaching method that places students in a real social engineering problem, is widely used in engineering education by solving problems by solving problems. This article takes the wireless sensor network course of Guangdong University of Science and Technology as an example. Through the construction of the project -based teaching model of engineering education, and the practice of this model in the course, explore the advantages and feasibility of wireless sensor online curriculum project -type teaching, and be new. The transformation and promotion of engineering education provide effective reference.

2. The Predicament of Traditional Teaching Mode

The traditional teaching mode is teacher-centered and focuses on knowledge transmission and exam evaluation. In

contrast, the project-based teaching mode with an engineering education orientation emphasizes student-centeredness and cultivates students' comprehensive and practical abilities through practical projects and problem-solving. Compared to the traditional teaching mode, there are several predicaments:

(1) Lack of practical application: The traditional teaching mode focuses on knowledge impartation and theoretical discussions but lacks hands-on practice and real-world application. Students' acquired knowledge is not practically applied or validated, hindering their understanding of practical scenarios and technical challenges.

(2) Low student engagement: The traditional teaching mode overly emphasizes knowledge transmission and theoretical discussions while lacking practical application and active student involvement. This leads to low student interest and engagement, resulting in suboptimal learning outcomes.

(3) Insufficient innovation capability: The traditional teaching mode emphasizes knowledge acquisition and theoretical discussions but fails to foster and challenge students' innovation capabilities. Consequently, students may exhibit rigidity and a lack of innovation when confronted with real-world problems and project practices.

(4) Outdated exam evaluation system: The exam evaluation system of the traditional teaching mode mostly revolves around knowledge mastery and theoretical discussions, neglecting assessments of students' practical and innovative abilities. As a result, it fails to accurately reflect students' overall qualities and practical application skills.

In summary, the traditional teaching mode has shortcomings and predicaments in areas such as practical application, student engagement, innovation capability, and exam evaluation system. It cannot meet the demands of modern education regarding the cultivation of students' practical abilities and comprehensive qualities.

3. Engineering Education-Oriented Project-Based Learning Model Construction

3.1. Connotation of the Engineering Education-Oriented Project-Based Learning Model

The engineering education-oriented project-based learning model is a teaching approach that revolves around students, focuses on solving real-world problems, and emphasizes practical skills, innovative abilities, and teamwork. This teaching model emphasizes the cultivation of interdisciplinary comprehensive capabilities, and it involves completing "authentic projects" through practical experiences to develop students' "real" skills and knowledge. The learning process of project-based learning typically consists of four fundamental elements: problem selection and design, implementation of solutions, evaluation, and timely completion. In the implementation process, both students and teachers collaborate, with teachers assuming the roles of guides and facilitators.

This model promotes student-centered and personalized learning. Compared to traditional classroom teaching, the engineering education-oriented project-based learning model places an emphasis on students' autonomous learning, utilizing various learning methods to stimulate their intrinsic motivation and explore their individual potential. By relying on authentic projects, this teaching model offers advantages such as higher authenticity, stronger interdisciplinary integration, better collaboration, and enhanced creativity. It helps stimulate students' curiosity and desire for exploration while fostering independent thinking, problem-solving skills, communication abilities, hands-on practical skills, and teamwork capabilities.

3.2. Construction of Engineering Education-Oriented Project-Based Teaching Model

The core of constructing the engineering education-oriented project-based teaching model lies in closely integrating teaching content and methods with real-world applications, starting from authentic problems, and designing challenging and practical project tasks. The construction process involves the following aspects:

3.2.1. Identification of Student Competency Goals

The exploration and implementation of the engineering education-oriented project-based teaching approach runs through the entire course teaching process. The formation of project competencies plays a crucial role in cultivating engineering talents. When developing project-based courses, it is essential to first identify the competency goals for students to ensure their ability to independently fulfill the requirements of course projects.

Firstly, in terms of fostering project competencies, it is necessary to establish clear, systematic, and scientific goal systems for developing engineering project capabilities and competencies. Secondly, during the project design and implementation process, emphasis should be placed on cultivating students' engineering practices and engineering competencies, comprehensively nurturing their engineering technical skills and innovation awareness. Lastly, in terms of teaching evaluation, a comprehensive assessment of students should be conducted from the perspective of project competencies, incorporating students' engineering practices

and competencies as important parts of teaching assessment.

3.2.2. Project Selection

Project-based learning has advantages such as strong practicality, interdisciplinary nature, and broadening of disciplinary perspectives. In the context of engineering education, selecting real projects that are closely aligned with the profession, moderately challenging, and of reasonable scale is crucial for project-based learning. When choosing projects, it is necessary to consider students' professional backgrounds and course content to ensure that the projects meet their professional requirements and knowledge goals. Additionally, the practical significance and social value of the projects should be taken into account to cultivate students' problem-solving abilities. Consideration should also be given to the scale of the projects to meet students' teamwork needs, as well as the difficulty level to effectively enhance students' practical and innovative abilities.

3.2.3. Staged Management of Projects

Staged management of projects involves breaking down the entire project into multiple independent modules, each with clear learning objectives and task requirements. This helps to divide the project into specific learning stages that can be easily assigned to students, thereby enhancing their engagement and teamwork. Connecting each unit of the curriculum to previous knowledge and integrating it with students' practical experiences is important. Furthermore, for better promotion of education, it is necessary to consider how to collaborate with society and establish the correct values and practical attitudes.

3.2.4. Project Practical Component

The practical component serves to assess the completion status of the projects and students' performance in project practice. The practical component may include communication, experimentation, thesis writing, etc. In the implementation process of project-based learning, emphasis should be placed on problem-oriented learning and inquiry, allowing students to gradually develop engineering qualities while solving problems.

Firstly, students should continuously explore engineering problems in practical projects and reveal the deep-rooted causes and key influencing factors behind those problems. Secondly, during the problem-solving process, students should consider the entire life cycle of the engineering project and raise questions regarding sustainability, effectiveness, and other aspects. Finally, it is essential to emphasize the cultivation of engineering qualities during practical experience, including engineering practical abilities, problem-solving abilities, and engineering innovation abilities, in order to truly nurture engineering professionals who can adeptly handle engineering practice.

3.2.5. Course Evaluation System

The evaluation system is an important component of project-based learning, aiming to comprehensively assess students' engineering practical skills and engineering qualities, providing robust support for the cultivation of engineering talent.

Firstly, the evaluation system should be based on the actual needs of engineering projects, establishing evaluation criteria and indicators to determine the feasibility, effectiveness, and learning outcomes of the projects, while allowing for timely adjustments. Secondly, the evaluation system should focus on quantitative evaluation, taking into full consideration students' engineering practice and professional skill

assessments. Lastly, when applying the evaluation system, differences and potentials among students with diverse backgrounds should be considered, flexibly employing evaluation indicators according to individual levels of proficiency.

4. "Wireless Sensor Networks" Course Project Path Construction

4.1. Project Goal Determination

With the continuous progress of industrialization and informatization, wireless sensor networks have been widely used in various fields such as smart manufacturing and environmental monitoring. Therefore, a deep understanding and application of sensor networks has become a necessary condition for engineering education. This course program is organized into four stages.

The first stage is the basic concepts and components of "Wireless Sensor Networks," including task allocation and interface architecture in sensors, the basic principles of wireless connectivity in sensors, and principles of data exchange between sensors and desktop or wired computers. The second stage is the connection of wireless sensors: protocols and mechanisms, which mainly includes the protocol stack structure of sensor connections, communication mechanisms between sensor nodes and base station nodes, and other related technologies. The third stage is programming and application of wireless sensor networks, teaching students how to utilize wireless sensor networks to solve real-world problems, including writing and debugging applications on wireless sensor networks. The fourth stage is the comprehensive experiment, which revolves around the topic of a smart home based on wireless sensor network technology. Through surveys on students and families' requirements, it cultivates students' comprehensive analysis and programming abilities in developing network-based client applications and localized projects.

4.2. Selection of Project Themes

To achieve project-based teaching with an engineering focus, it is necessary to select a project with practical application scenarios and real needs to ensure the practicality and effectiveness of the project. The goal of the Smart Vegetable Greenhouse project is to establish an intelligent greenhouse based on wireless sensor networks. It aims to achieve real-time monitoring and control of environmental parameters such as temperature, humidity, light intensity, and CO₂ concentration within the greenhouse. The system should be able to automatically adjust the greenhouse environmental conditions based on real-time data for optimal plant growth and yield. This project is of great significance for agricultural production and environmental protection. Moreover, its implementation involves multiple aspects of technology and knowledge fields, such as wireless sensor networks, embedded systems, and web development, making it ideal for project-based teaching with an engineering focus. To achieve this goal, we will design an engineering-oriented project-based teaching path for the Smart Vegetable Greenhouse project based on the following five steps.

4.3. Project Teaching Path

4.3.1. Goal Setting and Project Planning

1. Clarify the goals and requirements of the project: In this stage, students will be introduced to the background and goals

of the Smart Vegetable Greenhouse project in the classroom. They will be required to implement a wireless sensor network system capable of real-time monitoring and control of the greenhouse environment, and automatic adjustment of greenhouse conditions based on real-time data.

2. Plan project implementation: In this stage, students will plan the Smart Vegetable Greenhouse project, dividing the project into work items, tasks, and deadlines, and establish project progress control and tracking mechanisms.

3. Role assignment and task allocation: In this stage, tasks and roles will be assigned based on students' skills and interests, forming project teams and defining team cooperation and collaboration mechanisms.

4.3.2. Project Requirement Analysis and Design

Requirement analysis and design for the Smart Vegetable Greenhouse project includes sensor and actuator selection, network topology construction, and design of data acquisition and transmission methods. Based on the requirement analysis and design results, project implementation plans and task assignments will be established to ensure the smoothness and effectiveness of project implementation.

1. Selection of sensors and actuators: Based on the environmental parameters in the greenhouse, such as temperature, humidity, light intensity, CO₂ concentration, suitable sensors and actuators will be selected. The data acquisition and control execution methods will be designed based on these selections.

2. Construction of network topology: Based on the deployment of sensors and actuators, the network topology of the wireless sensor network will be designed, and data transmission and routing methods will be determined.

3. Design of data acquisition and transmission methods: In the implementation of data acquisition and transmission, factors such as data real-time performance, accuracy, and reliability will be considered. Corresponding data acquisition and transmission schemes will be designed to ensure the full realization of project goals.

4.3.3. Development and Testing

This stage involves project development and testing work, including hardware development, software programming, sensor deployment, data acquisition, and transmission testing. The project team will be divided into different groups responsible for different tasks and work items. Through cooperation and collaboration, the development and testing stages of the project will be completed.

1. Hardware development: Based on sensor and actuator selection and network topology design, hardware development and deployment will be carried out to ensure the stable and complete data acquisition and control capabilities of the system.

2. Software programming: Based on the construction of hardware and network structures, software programming and database design will be conducted to achieve real-time data acquisition, processing, and transmission.

3. Sensor deployment and testing: Sensor deployment and testing will take into account factors such as sensor location, data acquisition frequency, and data accuracy to ensure stable and reliable data collection.

4.3.4. System Integration

In this step, it is necessary to integrate and optimize the development achievements from various components to achieve system functionality and performance optimization. At the same time, system testing and performance evaluation

are conducted to ensure system stability and reliability.

1. System Integration and Optimization: In this stage, the development achievements of various components in the earlier stages are integrated and optimized to ensure system reliability and stability.

2. System Testing and Performance Evaluation: System testing and performance evaluation are conducted to assess system stability, reliability, and performance. Multiple aspects such as data transmission, data processing, data analysis, network connectivity, and response times are checked and tested during the testing and evaluation process.

4.3.5. Documentation and Report Writing

The project's development and testing results are documented, and comprehensive documentation and reports are prepared. These documents and reports should include system design, functional descriptions, testing procedures, test results, and performance evaluations to preserve the project's history and technical achievements.

1. Writing System Design Documents: In this stage, a detailed description of the system design is required, including design principles, implementation plans, data flow, and transmission methods for each component.

2. Writing Testing Documents and Performance Assessment Reports: After the testing process and performance assessments, a summary of the test results and performance evaluations is prepared through writing testing documents and performance assessment reports to preserve the project's history and technical achievements.

By implementing the above five steps, we can achieve project-based engineering education that enables students to master various technologies and knowledge in practice, enhancing their innovation and practical skills. In the Smart Greenhouse project, project-based engineering education can help students gain a comprehensive understanding of the application of wireless sensor networks and master the technical knowledge and skills in practical application scenarios, improving their abilities in engineering design and implementation.

5. Summary

This article introduces the challenges faced by traditional engineering education, explains the advantages of project-based teaching mode, and discusses its application using the example of wireless sensor network course at Guangdong

University of Technology. The key elements of project-based teaching mode are also listed, providing reference for other schools and institutions in carrying out project-based engineering education.

In more complex engineering and technological practices, such educational methods will become increasingly important. We should continue to explore how to gradually improve and optimize the existing educational models, providing students with deeper knowledge, higher skill levels, and stronger engineering practical abilities, laying a stronger foundation.

Acknowledgments

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