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Exploration of Teaching Mode of "Principle and Application of Single Chip Microcomputer" Course Based on Engineering Project

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Abstract: The engineering project-oriented training of applied talents has garnered increasing attention in contemporary engineering education. Addressing the prevalent issues in the teaching of the "Principle and Application of Single Chip Microcomputer" course in colleges and universities—such as an overemphasis on theoretical knowledge at the expense of cultivating students' practical abilities and innovative thinking—this study explores an engineering project-oriented teaching model for the course. By leveraging practical cases and engineering projects, this model emphasizes the development of student's practical skills and their ability to comprehensively apply theoretical knowledge. The proposed approach aims to enhance students' learning interests, comprehensive abilities, and innovation consciousness, thereby laying a robust foundation for their future professional development.

Keywords: Engineering project; Practice teaching; Strengthening practice; Innovation ability

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1. Introduction

Developing engineering students' ability to address real-world engineering challenges constitutes a central objective of engineering education certification [1]. As a core course in electronic information engineering, automation, mechanical electronics, and related disciplines, "Principle and Application of Single Chip Microcomputer" exhibits significant practical and applied value [2]. However, feedback from students and evaluations of current teaching outcomes reveal notable deficiencies in the course's theoretical instruction and experimental teaching. Specifically, the teaching model is outdated, and there is a lack of effective integration between theoretical instruction and laboratory activities.

In response to similar issues in other courses, researchers have examined engineering project-oriented teaching models that blend theoretical knowledge with practical application. By incorporating real-world engineering projects, these models enhance students' practical abilities and problem-solving skills [3-5]. Through an analysis of engineering project requirements, teaching content is restructured and optimized to integrate theoretical concepts with their practical applications, enabling students to better comprehend and master these theories [6]. Additionally, practical components such as course design and experimental exercises foster students' hands-on skills and problem-solving capabilities.

Furthermore, some researchers advocate involving enterprise engineers or industry professionals to provide on-site guidance and insights, thereby enabling students to understand industry demands and technological advancements more comprehensively [7]. Collaborative activities such as project presentations and peer exchanges are also organized, encouraging students to share experiences, learn collaboratively, and strengthen teamwork and innovation skills. The engineering project-oriented teaching model thus emerges as an effective approach that bridges theory and practice, equipping students with enhanced practical and problem-solving competencies.

Although research and exploration of the engineering project-oriented teaching model have achieved certain advancements, further studies and practical implementations are necessary to refine and optimize the teaching framework and improve instructional quality and outcomes. In this context, this paper investigates an engineering project-oriented teaching model for the "Principle and Application of Single Chip Microcomputer" course. The goal is to enhance students' learning engagement, foster comprehensive abilities, and establish a strong foundation for their future career paths.

2. The design of teaching mode

2.1. Integration and optimization of teaching content

To better address the needs of engineering projects, it is essential to deeply integrate and optimize the traditional teaching content of the "Principle and Application of Single Chip Microcomputer" course. This process involves not only the reorganization and adjustment of knowledge but also the inclusion of examples and cases related to engineering projects, thereby facilitating the combination of theoretical knowledge and practical application.

2.1.1. Integration and optimization of course content

The single-chip microcomputer (MCU) is a complex system, and its internal structure and division of functional modules can be challenging for beginners [8]. To address this, the course content is systematically divided based on the internal structure and functional modules of the microcontroller. This approach helps students better comprehend and apply the knowledge of single-chip microcomputers. For instance, emphasis is placed on topics such as the structure and function of the central processing unit (CPU), types and operations of memory, configuration, and usage of input/output (I/O) ports, implementation methods of timers/counters, and the principles and applications of interrupt systems. Through this structured teaching methodology, students can gain a holistic understanding of the single-chip microcomputer and the interrelationships among its functional modules.

2.1.2. Introduction of engineering examples and cases

While theoretical knowledge forms the foundation, its true value is realized when applied to practical engineering projects. Consequently, incorporating typical engineering examples and cases into the teaching process allows students to understand the practical applications of single-chip microcomputers in real-world scenarios [9]. Examples such as intelligent home control systems and industrial control systems based on single-chip microcomputers can be introduced. By analyzing and discussing these examples, students not only deepen their understanding of single-chip microcontroller applications but also enhance their interest and initiative in learning.

2.1.3. Cultivation of students' practical ability

In addition to traditional experimental courses, incorporating course design projects and school-enterprise collaborations can provide students with more opportunities to engage in practical engineering projects. This enables them to apply theoretical knowledge in real-world settings, thereby improving their practical skills and problem-solving capabilities [10]. Furthermore, collaboration with enterprises allows students to gain insights into industry needs and trends in technological development.

2.2. Strengthening practical teaching

Practical teaching is central to the engineering project-oriented teaching model, as it directly addresses real-world engineering challenges and enhances students' practical skills and innovative thinking. To effectively strengthen practical teaching, the following measures can be implemented.

2.2.1. Increasing experiment duration

In the "Principle and Application of Single Chip Microcomputer" course, experiments are critical for enabling students to apply theoretical knowledge in practice. Extending the duration of experimental classes and designing more projects with practical application value, such as digital clock design or light-emitting diode (LED) flicker lamp control based on single-chip microcomputers, provide students with greater opportunities for hands-on practice. This approach helps students better understand and master the practical applications of single-chip microcomputers [11].

2.2.2. Introducing course design

In addition to experimental classes, course design serves as an essential component of practical teaching. Students can be grouped to undertake system design and debugging tasks aligned with real-world engineering projects. This methodology encourages students to apply their knowledge of single-chip microcomputers to solve practical engineering problems independently or collaboratively. It enhances teamwork and problem-solving skills while providing a deeper understanding of single-chip microcomputer applications in engineering contexts.

2.2.3. Promoting school-enterprise cooperation

Collaboration between educational institutions and enterprises is an effective means of enhancing practical teaching. By organizing student participation in enterprise-led practical projects, students gain insight into the operational needs of businesses and technological advancements. Simultaneously, they apply their theoretical knowledge in real-world scenarios, thereby improving professional competence and practical skills. This approach also familiarizes students with industry operations and trends [12].

2.2.4. Organizing practical competitions

Regularly hosting competitions, such as single-chip microcomputer application design contests, allows students to apply their knowledge in practice while fostering peer learning and idea exchange. These competitions provide a platform for innovation and collaboration.

2.2.5. Providing practical guidance

Students often encounter challenges during practical teaching sessions. Establishing a guidance system or group to offer timely support and advice helps students address these issues effectively. This assistance ensures a smoother learning process and strengthens their practical problem-solving capabilities [13].

2.2.6. Updating practical teaching content

With ongoing advancements in science and technology and the evolution of engineering requirements, it is essential to regularly update the content of practical teaching. This ensures alignment with current industry needs and technological trends, keeping the curriculum relevant and effective.

By implementing these measures, practical teaching can be significantly enhanced. Students' practical abilities and innovative thinking can be cultivated, laying a strong foundation for their future professional development.

2.3. Diversification of teaching methods

A diverse range of teaching methods can effectively stimulate students' interest in learning and enhance their initiative. The following measures can significantly improve learning outcomes.

2.3.1. Developing multimedia teaching resources

Utilizing multimedia technology, such as animations, video demonstrations, and expert explanations, allows for the creation of engaging teaching materials and videos to help students better comprehend course content. These multimedia resources can be shared through the campus network or the Internet, enabling students to access and learn from them anytime and anywhere.

2.3.2. Facilitating online teaching and interactive communication

Online teaching and interactive communication can be conducted through platforms such as Chinese University Massive Open Online Courses (MOOC) and Xuetang Online, allowing students to learn flexibly. These platforms provide a variety of resources, including course materials, question banks, and discussion forums, enabling students to plan their learning schedules and locations independently [14]. Additionally, teachers can use these platforms to answer students' questions and guide their studies, fostering an interactive learning environment.

2.3.3. Organizing group discussions and case analyses

Group discussions and case analyses encourage students to express their opinions, fostering innovative thinking and communication skills. These activities also facilitate peer-to-peer learning, enhance teamwork abilities, and stimulate creative problem-solving. Teachers can leverage these sessions to gain insights into students' learning progress and challenges, enabling timely adjustments to teaching strategies.

By implementing the above measures, students' engagement, initiative, and comprehensive skills can be significantly enhanced. Furthermore, teachers must continuously update their knowledge and adapt their teaching methods to meet evolving educational demands and accommodate the diverse characteristics of students.

3. The implementation of teaching cases

To illustrate the application of the engineering project-oriented teaching mode for the "Principle and Application of Single Chip Microcomputer" course, a specific project, "Intelligent Home Control System Based on Single Chip Microcomputer," is used as an example. This project requires students to utilize a single-chip microcomputer to achieve intelligent control and remote management of home appliances [15].

3.1. Theoretical teaching link

The theoretical teaching phase introduces the internal structure and functional modules of the single-chip microcomputer, along with interface technologies relevant to home control, such as temperature sensors and infrared sensors. Specific cases, such as implementing temperature control for air conditioning or adjusting light brightness using a single-chip microcomputer, are analyzed to demonstrate practical applications. Additionally, theoretical knowledge related to engineering projects, including communication protocols and data transmission and processing, is covered to provide students with a comprehensive understanding of the microcontroller's applications and the practical requirements of engineering projects.

3.2. Experimental teaching link

The experimental teaching phase involves designing a series of practical experiments related to home control, such as temperature acquisition and control, lighting management, and automated curtain control. These experiments require students to master single-chip microcomputer programming techniques and the design and debugging of interface circuits. Independent innovation is encouraged, allowing students to explore additional home control functions with real-world value.

Teachers provide detailed experimental instructions and materials, organize operational activities, and facilitate discussions. Students must complete the experimental tasks within the designated time, submit reports, and reflect on their experiences. Teachers evaluate performance based on experimental execution and the quality of reports, offering guidance to deepen students' understanding of microcontroller applications and experimental techniques.

3.3. Course design link

The course design phase involves students working in groups to design and develop a project aligned with actual engineering requirements. This includes hardware circuit design, program development, and debugging. Students must also prepare a comprehensive project report and create demonstration materials, such as videos. This exercise cultivates teamwork and problem-solving skills.

Teachers provide project guidelines and related resources, facilitating group discussions and offering supervision. Students are expected to complete their projects and submit deliverables within the allocated time frame. Evaluation is based on project completion and the quality of submissions, with guidance provided to enhance students' understanding of single-chip microcomputer applications and the implementation of engineering projects.

Additionally, enterprise engineers or industry professionals can be involved to provide on-site guidance and insights into industry needs and technological advancements. Students may also participate in project showcases and exchange activities to foster peer learning, share experiences, and enhance teamwork and innovation skills.

The implementation process outlined in the above three phases demonstrates that the engineering project-oriented teaching mode for the "Principle and Application of Single Chip Microcomputer" course emphasizes integrating theory with practice. It prioritizes cultivating practical skills, innovative thinking, teamwork, and communication abilities. The incorporation of specific engineering project examples enhances students' interest and initiative, ultimately improving their practical abilities and problem-solving skills.

4. Conclusion and prospect

The project-oriented teaching mode for the "Principle and Application of Single Chip Microcomputer" course combines theoretical knowledge with practical application, effectively enhancing students' practical skills and fostering innovative thinking. By integrating and optimizing teaching content, strengthening practical teaching, adopting diversified teaching methods, and implementing specific engineering projects, this approach stimulates students' learning interest and initiative. Furthermore, it improves the overall teaching effectiveness and quality while cultivating students' teamwork and problem-solving abilities, thereby establishing a strong foundation for their future professional development.

Disclosure statement

The authors declare no conflict of interest.

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