Innovation and Practice of Teaching Computer Hardware Courses in English under the Background of New Engineering Discipline

——Taking Digital Logic as an Example

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Abstract. To address the issues of insufficient teaching materials and relatively boring traditional teaching methods in engineering hardware courses using English as teaching language, we proposed a student-centered case teaching method. Starting from reconstructing the course content, we have used common household appliance control circuits as teaching cases to bring fun to the classroom and increase student participation. We have also innovated teaching mode with a six-step teaching method of "leading, analyzing, inquiring, evaluating, practicing, and summarizing" to carry out case-based teaching, allowing students to shift from passive learning to active innovation. Furthermore, we have reformed teaching evaluation methods, introducing diversified and humanized evaluation modes that integrate assessment activities throughout the entire learning process. Students are encouraged to participate in competitions related to the course content, improving their knowledge through practical application. Currently, initial results of these teaching innovations have been seen. The "Digital Logic" course has been recognized as "Branded Course for International Students Taught in English" by the Ministry of Education of China and a national-level first-class undergraduate course. The teaching achievements have also received multiple university-level and provincial-level teaching awards, and students have won numerous awards in related competitions.

Keywords: Teaching Innovation, English-Teaching, Reconstructing course content, Student-centered, Digital Logic.

1 Introduction

In recent years, the globalization of the economy has accelerated the demand for international talents, and the "One-Belt, One-Road" initiative has attracted a large number of foreign students. To adapt to the new educational situation and cultivate students' international perspective, a number of course using English as the only teaching

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language have emerged in Chinese universities [1]. South China University of Technology began establishing English-teaching majors and courses in 2011, and "Digital Logic" was one of the first English-teaching courses established. This course is a fundamental professional course for computer science majors [2], offered in the first semester of the second year. It is the first course in the hardware curriculum system[3], mainly covering the analysis and design methods of combinational and sequential logic circuits, programmable logic devices, memories, and hardware programming languages. The aim is to cultivate students' ability to independently learn computer hardware knowledge, enabling them to describe, analyze, and design digital logic systems, as well as to design and debug complex digital functional components using new digital devices and hardware description languages.

In 2017, the Ministry of Education of China proposed the concept of "New Engineering Discipline ",which aiming to cultivate new engineering talents with innovative and entrepreneurial spirit, digital thinking, and cross-domain integration capabilities, providing intellectual support and talent guarantees for China's industrial development and international competition [4]. In this background, it is necessary to reform the "Digital Logic" course, keep steps with the development of hardware technology, reshape the course content, enhance the innovation and advancement of the course, adopt a "student-centered" teaching philosophy, and carry out case-based scenario teaching. This will fully mobilize students' interest and initiative in learning, train them into top talents in the field of computer science and technology with strong innovative abilities, a sense of patriotism, global perspective, and craftsmanship spirit.

2 Problems in the Teaching of "Digital Logic" Course

2.1 Insufficient International Teaching Materials

"Digital Logic" is one of the first English-teaching courses established in our university. The content of the English textbook used is not completely identical to the previous Chinese textbook, and Chinese teaching materials cannot be directly used in English-teaching [5]. Therefore, there is a lack of English teaching materials. To achieve good results in English-teaching courses, the following issues need to be addressed:

How can we introduce frontier industry technology into the classroom and reshape the relatively dry hardware knowledge to make it easier for students to learn and apply, stimulating their interest in autonomous learning?

How to create a variety of English teaching materials combining text, images, and animations to improve students' learning efficiency and understanding depth, while enhancing their learning enjoyment and effectiveness?

2.2 Problems with Traditional Teaching Organization Methods

"Digital Logic" is a hardware course with strong principles and can be relatively monotonous. When it is taught using English as the only language, students may experience difficulties such as poor English listening and easy distraction [6]. Traditional teaching activities are centered on teachers, which cannot mobilize students' initiative.

Students follow the teacher's instructions, learning what is taught, listening in class, and completing homework after class [7]. Such a teaching form cannot encourage students to learn independently. It is necessary to shift from the traditional teacher-centered approach to a student-centered approach in carrying out all teaching activities. Students should be the subject of learning, while teachers become guides in teaching. Students not only need to think independently but also need to learn how to integrate knowledge, exchange knowledge with others, and cooperate and assist each other to complete learning tasks.

3 Innovation Initiatives in teaching "Digital Logic" Course

3.1 Reconstructing the Teaching Content with Advanced and Innovative Elements, Enhancing the Challenge

Introducing Frontier Technologies, Integrating Teaching Cases, and Reconstructing Teaching Content

To provide students with innovative teaching content, the course team has reconstructed the course curriculum. Based on the latest English original textbooks and traditional Chinese teaching resources, the content related to number systems, coding systems, and CMOS circuits that overlap with other courses has been significantly reduced. Instead, introductions to hardware circuit design tools and hardware design simulations have been added, incorporating the latest frontier industry technologies into the classroom.

To enable students to learn the course knowledge both broadly and deeply, and to enhance the advanced nature of the course, the course team has integrated discrete course content and knowledge based on contextual themes. Popular circuits in daily life are transformed into teaching cases. Application examples such as blood type matching detectors, automatic starting switches for generator sets, priority queuing circuits, and multi-person voting machines are used to illustrate the practical applications of combinational logic circuits. Real-life instances like traffic light controllers, anti-jitter button circuits, arbitrary base counters, and 110 signal detectors are employed to explain the working principles of sequential logic circuits. Each case is designed with a corresponding application scenario, and the case-based content is introduced through scenarios in the classroom. This approach not only cultivates students' ability to solve complex problems but also increases the fun of learning and stimulates their desire for knowledge. In experimental teaching, comprehensive experiments (such as traffic signal lights, running lights, etc.) are used to deepen students' mastery of textbook knowledge and improve their hands-on skills.

In addition, the course team has modularized the relevant content from college student competitions involving hardware design, such as robot football and autonomous vehicle challenges, and introduce them into course design and extracurricular activities. This will encourage students with extra capacity to actively participate and invest more effort in solving challenging practical problems, thereby enhancing their comprehensive abilities and high-level thinking.

Creating English-based Teaching Materials to Enrich Instructional Resources

Building upon the reconstructed course content, the team has extracted key concepts and statements for each teaching topic, and produced teaching slides with accompanying images and Flash animations. The images used are sourced from the latest technologies, design concepts, and product trends in the computer hardware field both domestically and internationally. The slides are designed to be conceptually clear, highlight important and difficult points, and maintain strong logical coherence. In terms of presentation, they are visually appealing and intuitive, leveraging the students' comprehensive sensory capabilities to enhance learning outcomes while providing an enjoyable learning experience.

3.2 Reforming Teaching Methods to Improve Learning Efficiency

Adopting a Student-Centered Approach with a Six-Step Teaching Method for Case Studies

To enhance student motivation and learning outcomes, the course team adopts a student-centered approach. Based on the BOPPPS model [8], we propose a six-step teaching method to carry out case studies. This six-step approach are named as " leading, analyzing, inquiring, evaluating, practicing, and summarizing". The teacher first introduces the scenario and presents the objectives, allowing students to experience the situation and formulate questions. Subsequently, the teacher analyzes the case requirements and guides students to think through questioning. Based on this, students explore the logic of solving the problem, construct their thinking framework, and gradually solve it under the teacher's guidance. Following this, the teacher provides a detailed evaluation, assigns similar exercises, and finally guides students to summarize and extrapolate, turning them into the center of learning and transforming passive learning into active innovation.

Actively Carrying Out Extracurricular Extensions and Combining Competition with Teaching to Enhance Teaching Effectiveness

Hardware courses are highly practical, and the course team employs a combination of competition and teaching. We treat teaching as the foundation for competition and competition as an extension of teaching. Students are encouraged to participate in extracurricular activities, and guided to apply for innovative projects and competitions such as the "National Innovation Programs " and "Provincial Innovation Programs " with hardware design topics like robot football, RFID electronic tags, and embedded DVR. The team provides students with development tools and technical guidance, encouraging them to transform their knowledge of sequential logic from the classroom into offensive strategies on the competition field. Practice has shown that extracurricular competitions can effectively stimulate students' innovative spirit.

3.3 Reforming Evaluation Methods and Focusing on the Learning Process

Adopting Diversified Evaluating Methods and Integrating the Assessment Process into All Aspects of Learning

The course team adopts diversified evaluating methods, including classroom questions and answers (5%), homework assignments (25%), course labs (20%), and final exams (50%). The assessment process is integrated into all stages of learning, increasing the proportion of regular performance grades and striving to eliminate the cases of learning solely for the purpose of passing exams.

Adopting a Humanized Approach and Implementing Performance Evaluation from Multiple Perspectives

In classroom question-and-answer sessions and course labs, the assessment subjects are not limited to teachers. Student self-evaluation and peer-evaluation activities are conducted to give students the opportunity to examine their own achievements from the perspective of an evaluator, identify any shortcomings, and learn from the methods of others. This further enhances their understanding of knowledge.

4 Achievements and Promotional Value of the Teaching Reform

4.1 Recognition from Students and Excellent Evaluations

The lead teacher has consistently ranked first in student evaluations for five consecutive semesters in the college. In the most recent semester, the student evaluation score was 4.93 (out of 5), and the teacher has repeatedly received awards for excellent undergraduate classroom teaching quality from South China University of Technology.

4.2 Significant Enhancement of Elite Courses

After years of continuous construction, "Digital Logic" has not only been approved as an English-teaching course and an undergraduate teaching quality engineering project at South China University of Technology, but also designated as a "Quality Engineering" construction project for excellent resource-sharing courses in Guangdong Province, a Branded Course for international students taught in English by the Ministry of Education of China, and a national-level first-class undergraduate course.

4.3 Integration of Competition and Teaching with Remarkable Achievements

Over the years, students have achieved significant results in competitions related to this course, winning first prizes in the China Robot and RoboCup Open, national championships in the Cross-Strait Robot Soccer Invitational Tournament, second prizes in the University Curling Artificial Intelligence Challenge, and national championships in the Huawei Developer Contest - Unmanned Vehicle Challenge. They also received a

national gold medal in the 7th China International "Internet+" College Student Innovation and Entrepreneurship Competition in 2021.

4.4 Innovative Ideas and Award-Winning Achievements

The course team adheres to student-centered teaching and has achieved fruitful results, winning multiple teaching achievement awards, including the First Prize of the 7th Guangdong Provincial Awards for Teaching Achievements in Higher Education, the Second Prize of the Teachers' Teaching Innovation Competition of Guangdong Province, the Special Prize of the South China University of Technology's Teaching Achievements Award, the First Prize for Excellent Teaching at South China University of Technology, and the Second Prize in the Experimental Course Teaching Competition. The lead teacher was selected for the "2022-2023 Excellent Teacher Award Program for Computer Science in Colleges and Universities."

4.5 Creating Value and Promoting Applications

The new teaching philosophy and methods have achieved remarkable results, significantly increasing students' enthusiasm for learning and classroom participation, and resulting in frequent awards in extracurricular hardware design competitions. The reform outcomes can not only be used for the teaching of approximately 300 undergraduates in our college each year, but can also be extended to colleges offering related hardware courses, such as the Software School and the Network School. When conditions are ripe, the outcomes can also be shared with more sister institutions to benefit more students.

5 Conclusion

In the background of new engineering discipline, teaching innovation in English-teaching hardware courses should start with reconstructing the course content. Firstly, introducing common household appliance control circuits into the class can increase the fun of classroom teaching and enhance students' initiative and enthusiasm for learning. Incorporating industry-leading hardware design tools ensures that the course content keeps up with the times, providing seamless integration for students to participate in hardware design work after graduation and increasing the practicality of the course. Secondly, teaching methods need to be reformed by abandoning the traditional teacher-centered approach and adopting interactive teaching to break the monotony of the classroom, shifting roles, and implementing student-centered teaching to increase student participation. Thirdly, we should enrich our teaching methods with the use of course websites, animation courseware, and other forms to effectively complement classroom teaching. By fully utilizing modern information technology, we can cultivate students' ability to independently learn computer hardware knowledge from multiple dimensions and all aspects. Finally, we encourage and help students to participate in competitions can enhance their innovative abilities in practice, train them to top talents in the field

of computer science and technology with solid basic knowledge, strong practical abilities, and a global perspective.

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