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Innovative Exploration of Theory-Practice Integration in Electronic Technology Based on Hierarchical Project-Based Teaching

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Abstract: Electronic technology is a basic course for undergraduate non-electrical majors. The goal of the course is to let students establish the basic concept of electronic information engineering, train the ability of electronic circuit analysis, and establish the engineering thinking of electronic technology. This paper aims at the key problems in the electronic technology course education, and puts forward the solution ideas based on project-based teaching. Based on the teaching concept of OBE, the teaching innovation design of the curriculum is carried out from top to bottom, the teaching objectives of knowledge, ability and literacy are reshaped, the three-level teaching strategy of data-driven, team discussion and competition-led is formulated, and three main lines of teaching activities including teaching, discussion and engineering practice are designed, thus forming an online and offline mixed teaching paradigm based on hierarchical project-based teaching. It provides a new teaching reform idea for the construction of similar courses in China.

Keywords: Electronic technology; Project-based teaching; Physical integration; Teaching innovation

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1. Introduction

"Electronic Technology" is an undergraduate non-electrical professional basic course, teaching objects for mechanical, chemical, automotive, rail, aviation and other non-electrical engineering majors, is a theoretical and practical engineering bridge course, to allow students to use the brain and hands-on combination, experience iterative engineering design and innovation [1,2]. This course is the only basic course of electronic information for students, and the follow-up course is the engineering practice application of electronic information engineering in various majors. If students do not learn how to use electronic circuits in the electronic technology course, they will not be able to use electronic technology to solve professional engineering problems in the follow-up professional courses.

The course orientation is to build electronic course content with information and control as the main teaching elements, help non-electrical engineers and managers to establish a relatively complete knowledge system

framework on electronic information engineering, acquire the ability to communicate with telecommunications engineers on professional needs and collaboratively solve complex engineering problems, and cultivate students' rigorous and practical engineering literacy to stimulate students' national feelings of rejuvenating the country through science and technology [3,4].

Since 2018, the teaching team has carried out teaching innovation design, carried out online and offline mixed teaching, completed four rounds of teaching reform, and gradually reformed and improved online resources and teaching methods. In 2021, it was recognized as the first-class online and offline mixed course in Shanghai and won the first prize of Shanghai University Teachers' Teaching Innovation Competition and the Teaching Academic Innovation Award.

2. Pain points and solutions of the course

2.1. Course pain points

(1) Students' mathematical foundation is polarized and their learning participation is low. Students majoring in non-electrical subjects generally believe that electronic technology has nothing to do with their major and their interest in learning is not high. The traditional lecturing teaching method has delayed feedback, and the teaching effect cannot effectively close the loop, which is contradictory to the personalized learning needs of students.

(2) Electronic technology emphasizes application, while students emphasize knowledge memorization, and their advanced ability is insufficient. Students are used to applying the formula to solve the problem mode, and the characteristics of electronic devices are nonlinear and strong engineering, electronic circuit analysis has a large number of "ignore" and "equivalent," students are difficult to understand, will not use after learning, forgetting rate is high.

(3) The course content focuses on basic components and underlying hardware circuits, and students feel that there is no challenge. Students do not understand the necessity of basic knowledge, electronic technology is developing rapidly, and some students have come into contact with the single chip microcomputer, Arduino, and various modules, thinking that these discrete components, basic circuits, small-scale chips are outdated, not interested in learning.

2.2. Solution

When doing teaching innovation design, the first thing to be clear is the concept and goal. The teaching object of this course is non-electrical engineering students, who are Internet natives. They have strong information acquisition ability, but are used to taking tests. They have strong interest in engineering, but weak practical ability.

China's hardware and electronic equipment, in many industries, need innovative talents, students from the quality, the courage to challenge, excellence, independent innovation, the heart of the country, the future can apply electronic technology to their professional field. To give them challenging projects, in the teaching process, guide students to change their learning methods, from the teacher to teach to learn, to achieve the improvement of engineering ability, from being able to do problems to doing things [5,6].

To achieve the goal of literacy, we must start from basic knowledge, the basic knowledge of electronic technology is to identify electronic components, judge the circuit function, and calculate the characteristics of the parameters before the teacher tells the students that these components are so. The knowledge of these

components is very important, but the learning of engineering cannot rely on a lot of memorization but needs rational reasoning. Students should be able to think independently, from knowing what they are, to why, and then to how to use them, and finally reach the thinking goal, with hardware thinking as the starting point, laying a good foundation, with engineering thinking as the path, building steps, with innovative thinking as the guide, climbing the peak. In this process, the engineering project is the traction, practical integration to assist students to explore, to seek knowledge [7,8].

3. Teaching design and implementation

The teaching team introduces the output-oriented education concept into teaching practice [9,10], divides teaching objectives into three levels, divides teaching strategies and learning tasks into three levels, and designs hierarchical engineering practice projects through three main lines of teaching activities, combined with discipline competitions, to help students build a ladder and reach teaching goals step by step.

3.1. Three-level teaching objectives

In combination with the school's positioning of "high-level applied undergraduate" and the country's demand for "excellent engineers," the curriculum objectives of the third level of knowledge, ability and quality thinking are formulated.

(1) Knowledge objective: To be able to identify basic electronic components and integrated circuit chips, to be familiar with the performance and characteristics of semiconductor devices, to explain the basic concepts and analysis methods of electronic circuits, to explain the analysis and design principles of electronic control circuits, and to build a relatively complete knowledge system architecture of electronic information engineering.

(2) Ability goal: The ability to apply basic circuit laws and analyze complex electronic circuits through mathematical tools, the ability to design, simulate, build, debug and troubleshoot electronic circuits, the ability to communicate with electronic engineers on the needs of the profession, and the ability to cooperate to solve complex engineering problems.

(3) Quality, education and thinking goals: Have the habit and ability of independent learning, strong communication skills, innovative thinking and team spirit. Cultivate the craftsman spirit of excellence, rigorous and practical engineering quality and patriotic feelings of science and technology to rejuvenate the country.

3.2. Three-level teaching strategy

Aiming at the three-level dimension of the teaching objective, the three-level teaching strategy integrating science and reality is formulated. For knowledge objectives, we should lay a solid foundation, adopt practice while speaking, practice-oriented, data-driven, and accurate help. For the ability goal, to solve problems, adopt group discussion, team learning, project-driven, stimulate interest. For the goal of quality thinking, it is necessary to systematically improve, and adopt inquiry learning, example demonstration, competition guidance, and individual projects. In the three-level teaching, we should integrate the elements of rigorous and realistic, applying knowledge to practice, and thinking and politics of the craftsmen of great countries.

The teaching content is reconstructed, 9 key issues in the knowledge structure of electronic technology are found as supporting points, stratified projects are set up according to the increasing challenge degree, and the

scattered and fragmented teaching content is integrated and reconstructed according to the content of discipline competitions. All the project tasks are divided into three layers: the bottom line task that individuals must do, the ability task of group cooperation, and the challenge task that individuals choose to do. Step by step, build a ladder to develop students' technical communication ability and the ability to cooperate to solve complex engineering problems [11].

Small discoveries of electronic circuits, student number coding circuits and student number cycle display circuits are projects that must be completed independently. Differentiated engineering requirements make students unable to fish in troubled waters and hold the bottom line of course learning. Co-emission amplifier circuit, OP-amp mixing circuit and smart city lighting system are teamwork projects, organizing students to work together, project reporting and project practice. Audio circuit engineering analysis and intelligent circuit logic judgment are selected challenges.

3.3. Three main lines of activity

The teaching feedback flow of three main lines of activities is shown in **Figure 1**. For each key issue, the main line of teaching is adopted for the knowledge objective, the main line of discussion is adopted for the ability objective, and the main line of practice is adopted for the thinking literacy objective. Step by step, build a ladder to cultivate students' technical communication ability and the ability to cooperate in solving complex engineering problems. From component to system, establish the overall view of the system, and gain true knowledge in practice [12].

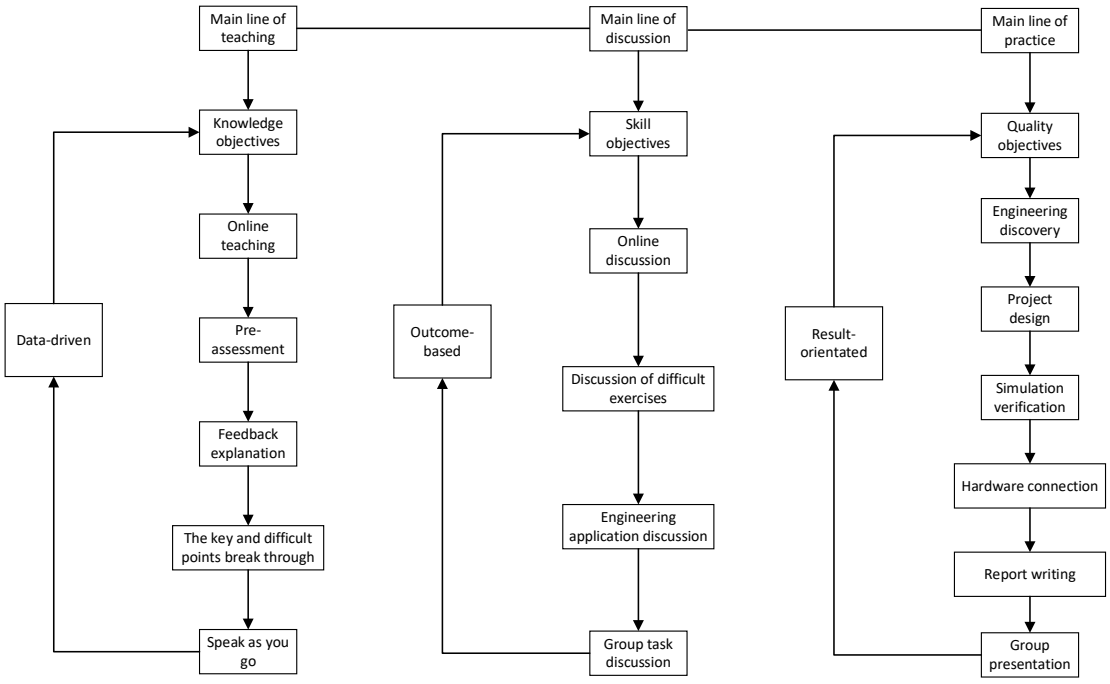

Figure 1. Main line of teaching activities: teaching + discussion + practice.

In the course implementation process, the BOPPPS model of "introduction, objective, pre-test, participatory learning, post-test and summary" has been adjusted, and the objective has been moved to the link of online introduction [13,14]. Given the relatively poor mathematical foundation of students in the school, we emphasize the breakthrough of key and difficult points in participatory learning and adopt problem-driven, practice-integrated

and project-based teaching methods in offline classes. The teaching process of online and offline double closed loop.

(1) Lecturing main line

For the basic electronic circuit concepts and principles and other knowledge objectives, the main line of lecture-style teaching, students online SPOC learning, online talk - offline test - feedback talk - difficult breakthrough talk - talk while practicing. Use the learning APP to send test questions to understand the students' memorization, through data-driven, multiple rounds of targeted explanation for the answer situation, real-time correction of students' false memory, to achieve "accurate teaching."

(2) Discuss the main line of learning

In view of the application of theorems, analysis and design of electronic circuits and other energy-oriented goals, output-oriented, online discussion of data retrieval -- group discussion of difficult exercises -- open discussion of engineering applications -- PBL project discussion, in the process of peer learning, students encourage each other positively and strengthen students' ability training.

(3) Mainline of engineering practice

Aiming at the goal of engineering literacy, it focuses on hierarchical project-based teaching, engineering discovery - project design - simulation verification - report writing - report display, so that students can become the main body and center of teaching. Results-oriented, through project-style teaching, we can realize the challenge of the course, cultivate students' engineering concept and ability to solve complex engineering problems and send more talents for discipline competitions.

3.4. Teaching evaluation

In the teaching evaluation, the whole process and multi-dimensional evaluation method combining process evaluation, performance evaluation and final evaluation is adopted. The online score is 25%, which is mainly scored by the completion of knowledge points, online tests and discussion rumination ratio. The offline average score is 20%, and the score is based on interaction such as classroom flipping, homework and project-based homework. In-class experiment scores 5%, according to the experimental performance, experimental report score, the final and ordinary classes to participate in the unified exam, exam score accounted for 50%.

Process evaluation data, the online part comes from the online platform SPOC, including video learning data, interactive discussion and online tests, which are mainly used to feedback and test the achievement of knowledge goals. The offline part comes from the intelligent teaching tool "Learning Tong," which includes the interactive feedback of teaching and practicing in class to detect the achievement of important and difficult content. The group discussion and homework results include teacher evaluation and student mutual evaluation, which can not only promote team cooperation but also enhance the peer effect and promote the development of middle school students. Project-based homework reporting results are combined with teacher evaluation, intra-group and inter-group mutual evaluation. Through students' technical reporting of works, students' technical communication and evaluation abilities are promoted.

4. Explore ideological and political elements

"Electronic Technology" as a basic course of engineering, has a very rich curriculum ideological and political resources. Through discussion teaching and project teaching, the course ideological and political education is integrated with professional education. Combined with the characteristics of mutual dependence and mutual

restriction between magnification and stability of amplifier circuit, the dialectical materialist thinking logic in engineering is discussed with students. Combined with the systematic operation circuit, the concept of balance and wholeness in Chinese traditional culture was discussed. Combining with the development process of chip technology in China, this paper discusses the difference between Chinese and Western science and technology with the historical materialist world view.

In the knowledge module, knowledge point, specific case layer by layer refinement, the ideological and political elements combined with teaching content, so as to be smooth and silent, the educational elements implemented into the knowledge point and specific projects, do not speak ideological and political words, but always in the thinking and political [15].

Taking the operation circuit of integrated operational amplifier as an example, the Chinese standard of integrated operational amplifier is different from the American standard, and the importance of technical standards is explained to stimulate students' patriotic feelings of science and technology to rejuvenate the country. In the analysis basis of the operational circuit, the simulation results are used to cut in, the analysis of the electronic circuit contains dialectical thinking, and there are trade-offs in engineering issues. In the operation amplifier mixing circuit design project, through the group cooperation to cultivate the spirit of teamwork, in the simulation verification, to promote the students to know and do.

5. Practical effect

After four years of course iteration and teaching design improvement, the course has been achieved. Through the guidance of ideological and political content, solve the problem of "why to learn" and "for whom to learn," solve the problem of "what to learn" and meet the requirements of personalized learning through online SPOC courses combined with offline feedback and explanation, solve the problem of "how to learn" in in-depth participatory discussion learning, solve the problem of "how to learn" through information wisdom teaching, and solve the problem of "how to learn" in project-based teaching to solve the problem of "how to use it" and carry out high-level engineering thinking training.

5.1. Data-driven and accurate teaching to promote the overall achievement of students

In 2022, the class carrying out blended teaching has a significantly higher achievement degree from curriculum objectives than the ordinary class (**Figure 2**). In the after-class survey, students' feedback that blended teaching has "great benefits" and "promoting effect" accounts for 46.4%, and only 2.3% of students think it has "little effect" on the learning effect. Compared with other courses, 80.5% of the students think that the effect of electronic technology adopting blended learning is "very good," and 19.5% of the students think that the effect is "about the same."

5.2. Students' advanced ability cultivation

In the feedback survey of learning effect after the course, the proportion of students who think that they have acquired "strong" self-learning ability through the electronic technology course is 89.49% in the mixed class, which is higher than that of the ordinary class (82.48%). The proportion of students who believed that they had "strong" troubleshooting ability of electronic circuits was 84.93% in the mixed class and 79.34% in the ordinary class. The proportion of students who thought that the ability to use simulation software was "very good" or "good" was 88.49% in the mixed class and 79.34% in the ordinary class. It can be seen that the blended teaching mode

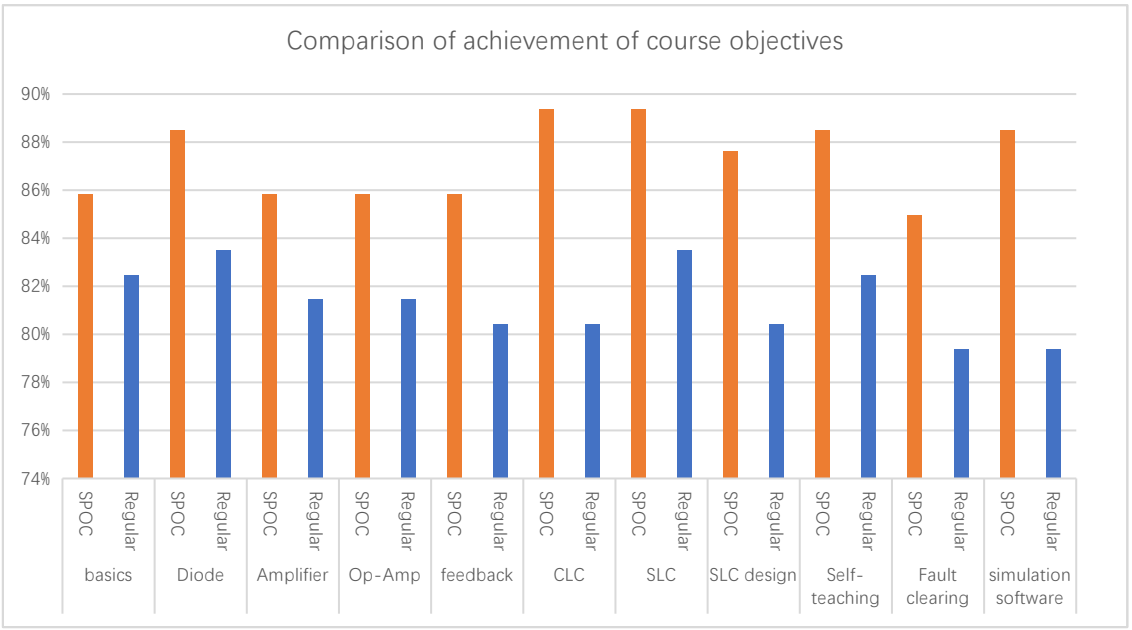

Figure 2. Comparison of goal achievement degree between blended class and ordinary class.

of three levels, three layers and three main lines has significantly improved students' advanced ability.

5.3. Project-based teaching challenge promotes discipline competition

Some excellent students stimulate the enthusiasm of competition and join the competition team through the selected challenge competition projects. The number of students in the latest teaching reform class who joined the intelligent team accounted for 11% of the total number of the class and 22% of the total number of new personnel in the team. In the past three years, the students have participated in electronic design competitions, "Siemens Cup" China Intelligent Manufacturing Challenge, "NXP" Cup Intelligent Car Competitions and other discipline competitions, and won 28 national awards and 50 provincial and municipal awards.

5.4. Teachers' teaching level improved

In the process of teaching reform, the teaching ability of the team members has been greatly improved. The main lecturer won the first prize of the National Electrical Engineering Teaching Competition, participated in the Shanghai University Teachers' Teaching Innovation Competition, won the first prize of Shanghai and the teaching academic Innovation award, and was rated as the school-level excellent main lecturer. Some team members have been awarded as excellent instructors by the Municipal Education Commission for three consecutive years, and some team members have won the national first-class excellent instructors of the National Intelligent Car Competition for college students many times.

6. Summary

In the electronic technology course teaching, taking layered engineering projects as the teaching entry point can make students become the main body and center of teaching, improve the challenge degree of the course, and cultivate students' engineering concept and ability to solve complex engineering problems. By reshaping the three-level teaching objectives of knowledge, ability and accomplishment, formulating three-level teaching

strategies, and designing the main line of three teaching activities of "teaching + discussion + practice," teachers organically combine online courses with offline classes. Through SPOC, Learning Pass and other modern information means to achieve timely feedback in online and offline teaching, data-driven teaching, covering every teaching link before class, during class and after class, to achieve personalized teaching and effectively solve the original pain points of the course.

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Disclosure statement

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