

Teaching Research on Exploratory Experiments in Science and Engineering Courses in Universities

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Abstract—Higher education is an important part of education and plays a key role in cultivating students' innovative ability. Both with strong theoretical basis and practical ability for college graduates has been put forward in the modern society, and experiment can train these abilities in the university education stage. Taking the specific application of exploratory experiment in electronic technology course as an example, this paper studies the teaching objectives, design guidance of the exploratory experiment course, and implementation and assessment methods of the new mode in the exercitation course of electronic technology in South China University of Technology. The results show that the exploratory experiment mode is beneficial to cultivate students' engineering project awareness, preliminary scientific research ability and comprehensive innovation ability, etc.

Keywords—Exploratory experiments; Practice course; Innovation; Electronic Technology

I. INTRODUCTION

Innovation is an inexhaustible motive force for flourishing and developing a country. Strengthening the ability of independent innovation is important in the new era. Higher education is an important part of education and plays a key role in cultivating students' innovative ability. High requirements for college graduates has been put forward in the modern society, including possess solid theoretical basis and strong practical ability. Experimental teaching is an important part of the undergraduate stage in Colleges and universities, which can make students mastering the basic knowledge, methods and skills of basic and professional experiment, and improve their innovative ability [1].

Experimental project is the basic unit of experimental teaching content, which include demonstrative, verifiable, comprehensive, design and exploratory experiments, etc. Demonstrative experiment is generally operated by teachers and carefully observed by students, and relating theories, principles and methods are verified by demonstrating experiments. Verifiable experiments are operated by students, so that students can deepen their understanding of basic theories and knowledge and master experimental skills, methods, skills and experimental data. The comprehensive experiment is a combination of static and dynamic synchronous experiments under the same condition, the experimental content can be the synthesis of one or more courses within the discipline, or the integration of interdisciplinary. Designed

experiment is a kind of heightening experiment in which students independently consult the data according to the given experimental purpose and requirement, design the experimental scheme and carry it out by themselves. Comprehensive and designed experiments are more complicated and systematic [2]. Exploratory experiment is a kind of experiment in which students use multi-disciplinary knowledge, synthesize multi-disciplinary content and combine with the teachers' scientific research and projects, enable students to grasp the scientific thinking mode and scientific research methods, and learn to write project reports[3]. Exploratory experiment is higher than the previous ones. Students who choose this mode must have better foundation and can carry out the exploratory experiments in groups, which is conducive to cultivating their abilities of innovation, comprehensive and preliminary scientific research, etc.

Exercitation course of electronic technology is an important basic practical course in science and engineering colleges, the main task of the course is to cultivate students' practical and innovation abilities in designing electronic circuit, making circuit board, mastering modern technology in electronic industry, installing, welding and debugging, etc. This course plays an important role in improving students' ability to handle and analyze practical problems and cultivating students' innovative consciousness and rigorous work style. It is conducive to their follow-up professional experiments、 curriculum design、 graduation design and so on. In addition, it lays a good foundation for practical and innovative work in the future.

The exercitation course of electronic technology in South China University of Technology (SCUT) is offered to over 2000 students from 20 departments and 40 majors every year. The current teaching mode is basically conducted in a fixed way of concentrating one week (students from non-electrical majors) or two weeks (from electrical majors). In this mode, teachers require students with strict standards, and students need to complete the experiment contents in a fixed time. However, different students have different foundations and learning abilities, they adopt the fixed experiment mode passively, so the initiative and creativity of the students have not been explored. But, in the exploratory experimental mode, Students need to investigate、 design、 produce and implement the project offered by themselves or from their teachers, so it can solve the problem of "passively-adopted" for these students,

and has a great role in improving students' engineering project awareness and innovation ability.

So, taking the application of exploratory experiment in the exercitation course of electronic technology in SCUT as an example, this paper studies the teaching objectives, schematic design of the exploratory experiment course, implementation method, and evaluation mode of the exploratory experiment in the teaching of science and Engineering in Colleges and universities.

II. TEACHING OBJECTIVES, DESIGN AND GUIDANCE, IMPLEMENTATION AND ASSESSMENT METHODS OF EXPLORATORY EXPERIMENT PROJECTS

A. Teaching objectives

Fig. 1 shows the sketch of the ultimate goals of the exploratory experiment mode, which incorporates the student-centered, results-oriented and continuous improvement teaching concept of OBE education model [4]. Exploratory experimental projects are selected as carriers to train students' abilities including design innovation, software application, hardware implementation and debugging capabilities, and resolving process problems, etc. The ultimate goal is to cultivate the students' practical and innovative ability, preliminary scientific research ability and ability to solve complex engineering problems. In the process of experiment, we insist on taking students as the center and give full play to their subjective initiative.

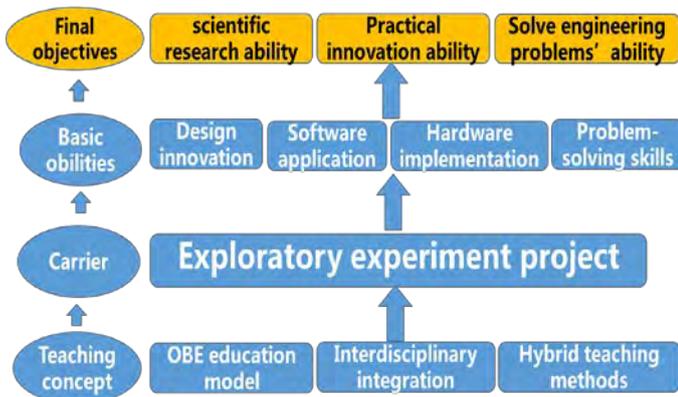


Fig. 1. Sketch of the ultimate goals of the teaching mode of exploratory experiment

OBE is abbreviation of Outcome-based Education [5]. It refers to the clear focus and organization of each links in the education system, and the determination of the learning goal, around which students can achieve the expected results after completing the learning process. The core elements of the OBE education model are: "student-focused", "results-oriented" and "continuous-improved" [6,7]. The OBE education model emphasizes that the students' learning results are the driving force, and according to the learning results, teachers need to optimize the teaching links and content, update teaching methods, and pay attention to the evaluation of students' learning effects. In the teaching process of colleges and universities, OBE education mode is mainly used in the field of engineering education. The introduction of OBE education

mode into the course electronic process practice is conducive to cultivate students' subjective initiative, improve their abilities of solving problems and innovation, etc.

B. Design and guidance

The design and guidance of exploratory experimental projects are embodied in the various links shown in Fig. 2, which including: (1) Guiding students to understand the research background and related fields, expand their thinking, and concept the project boldly and innovatively; (2) Guiding students to follow the industry development trend and leading technology closely and to find out the relating references widely and accurately; (3) Guiding students to design experimental schemes, define the system functions of the experimental projects, determine the work procedure, plan the system structure and divide the system modules. Encouraging students to innovate and design different implementation schemes; (4) Guiding students to Analyze the feasibility of the design schemes, understand and compare them in details. It is suggested that they should study modularized and choose the best design scheme. (5) Guiding them to master certain professional skills, to learn the use of relevant software and the operation of process and equipment related to circuit board making, to test and analyze the faults and system vulnerabilities and to find out the reasons and solve them reasonably; (6) Organize students to make reply in the form of PPT and project material, and summarize and communicate between different groups. At the same time, setting up innovative points through the performance evaluation criteria can inspire students to expand thinking, innovating, to further extend and optimize the project. Fig. 2 shows the specific design and guidance for the teaching mode of exploratory experiment projects.

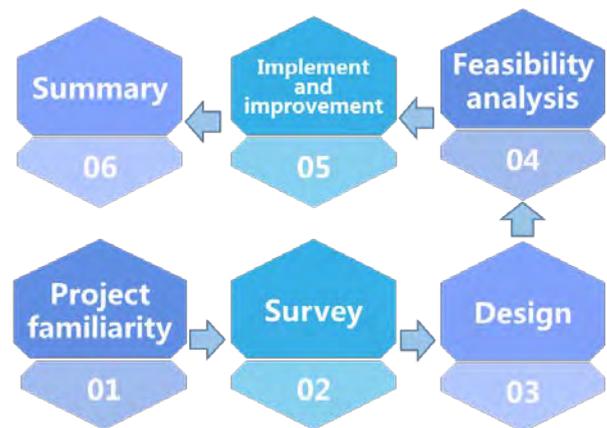


Fig. 2. Specific design and guidance for the teaching mode of exploratory experiment

C. Teaching method

Nowadays, the society has entered the digital age, and the knowledge presents the form of digitalization and networking. The shift from higher face-to-face education to online or blended mode of higher education has become a trend in the future [8]. Web-based learning system commonly known as Learning Management System (LMS) which makes use of

internet technologies has been widely used by many education institutions around the globe [9]. In the exploratory experiment, we adopt online and offline blended experimental teaching method, online teaching refers to use the websites of exercitation course of electronic technology, wechat public platform, etc. Offline teaching refers to guide and do the experiments in the laboratory. Fig. 3 shows the blended teaching method in the exploratory experiment mode.

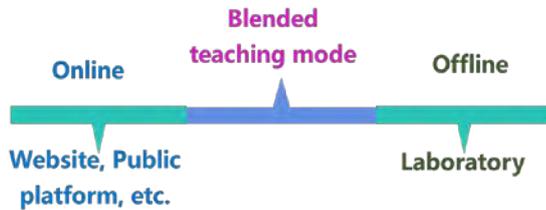


Fig. 3. Blended teaching mode in the exploratory experiment

D. Course assessment method

After completing the project, the student will submit the prototype of the experimental project, summarize the report and make a reply to the project. The specific performance contents and proportion are: 1) physical prototype (50%), which includes the quality of the design, functional completeness and performance. The quality of the design includes the rationality, standardization and innovation. Functional completeness and performance take the stability of equipment, reliability, electronic circuit welding quality and assembly process into account. 2) Project achievement defense (20%, 10% of which is the innovative score), which includes the background of knowledge field, application value, function conception, system design, technical process, technical difficulty, goal realization, practicability, innovation, ability cultivation and expected results involved in the experiment. 3) Project summary (30%), which includes the data's reliability and authenticity, content integrity, standardization and rigor.

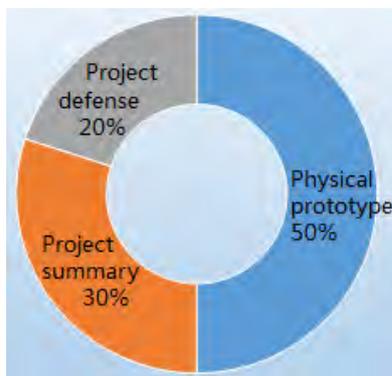


Fig. 4. Course assessment contents and proportion

III. CONCLUSION

By implementing the core concepts of "student-centered", "achievement-oriented" and "continuous improvement" in OBE education model, this paper studies the teaching objectives, teaching design and guidance, concrete implementation methods and course assessment methods of the open

exploratory experiments mode, and expands the original fixed practice model in the exercitation course of electronic technology in SCUT. Meanwhile, the reformed teaching methods, hybrid teaching form, and the reformed curriculum assessment methods are studied in this paper. The teaching effect is good through the evaluation results of the project and the feedbacks of the participating students. One of the project of the open exploratory experiment mode were cheese out to participate the Fifth National College Electrical and Electronic Basic Course Experimental Teaching Case Design Competition of China in 2018, which won the first prize and the best engineering design prize. The OBE-oriented open exploratory experiment teaching mode was unanimously approved by the evaluation experts. Generally speaking, the open exploratory experiment mode is beneficial to cultivate the students' engineering project consciousness, innovation consciousness and preliminary scientific research ability, etc.

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