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Outcome-based Education for Comprehensive Experiments in the Field of Electronics

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Abstract

This paper provides an overview of the reform of comprehensive-experiment instruction in the electronics discipline based on an outcome-based education (OBE) model. This approach is guided by the principles of engineering education accreditation, based on the characteristics of the electronics field and combined with existing comprehensive-experiment teaching conditions. In the OBE approach, experimental projects and content are designed using a student-centered approach, and comprehensive-experiment education objectives and assessment methods are formulated based on learning output. Moreover, project-based comprehensive-experiment education is implemented, and continuous improvements are made. The OBE approach can further enhance students' independent learning, innovation, and practical engineering abilities.

Keywords

Outcome-based education; Comprehensive experiment; Continuous improvement.

1. Introduction

China joined the Washington Accord in June 2016 to align engineering education in China with international standards. The Washington Accord is an international agreement between accreditation bodies regarding the mutual recognition of undergraduate engineering qualifications. With the development of science- and technology-oriented universities in China, major domestic universities have developed professional certifications and promoted outcome-based education (OBE) [1–2]. Many programs in the author's school have met the requirements for the Ministry of Education's "China Engineering Education Accreditation," and the electronics program is currently preparing to apply for accreditation. Engineering accreditation tends to focus on the practical skills students gain, the organization and implementation of practical education, and the cultivation of students' abilities through teamwork. In this regard, the "student-centered" approach is oriented toward students' practical education outcomes, aiming to ensure quality education [3–4].

Based on the characteristics and objectives of electronics programs, the courses for each electronics major basically consist of three main parts: theory courses, basic experiments, and comprehensive experiments. Basic experiments focus on validating a single piece of knowledge. They are generally conducted as in-class experiments, with each experiment lasting about two class hours. Each course essentially consists of 8–10 hours' worth of basic experiments. Basic experiment and theory courses are conducted simultaneously, following the pace of the theory class. The main purpose is to physically verify theoretical textbook knowledge through experiments, gain a deeper understanding of theoretical knowledge, and lay the foundation for deeper study in the next step.

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Comprehensive experiments are used to verify and apply multiple interrelated pieces of knowledge from a course, aiming to refine and summarize what was learned in the course. Comprehensive experiments take the form of separate lessons and are basically scheduled for one week. Basic and specialized courses in the major have their own comprehensive experiments. The purpose is to help students systematize their knowledge after completing a course. Based on the course, they should be able to carry out a complete design to achieve an expected outcome and evaluate overall application capability.

2. Existing Problems With Comprehensive Experiments

(1) The educational goals of comprehensive experiments are not clear-cut, and they are not sufficient to support graduation requirements. Comprehensive experiments are not scientifically rigorous, and the achievement of practical education goals is not sufficiently clear. Moreover, the methods, measures, and evaluations used to ensure the achievement of educational goals cannot adequately support the educational goals of graduates.

(2) The "teacher-oriented" instruction method lacks innovation in practice. Comprehensive experiments still typically rely on content, procedures, and methods designed by the teacher and are merely completed by the students as prescribed. This teaching method is misaligned with the philosophy of OBE and the student-centered principle, making it difficult to cultivate a sense of innovation in students. Although students are encouraged to apply themselves in practice, they are weak at solving practical problems and lack innovative awareness. The result is a major discrepancy between needs and expectations and actual outcomes.

(3) The content of comprehensive experiments is often simplistic and lacking in relevance. Since the practical teaching system is neither perfect nor scientific, the relevance of comprehensive experiments in each course is relatively weak, and they can even be repetitive. There is a lack of horizontal relevance and vertical depth at the level of theoretical knowledge, and the traditional process-oriented teaching method tends to ignore the fundamental goal of "learning results" for students. It is also difficult to form a quality assurance mechanism for continuous improvement.

(4) The comprehensive-experiment instruction process is too rough, and it is impossible to carry out flexible teaching and guidance according to different students' levels. Because of the actual situation of the author's school, teaching is restricted by venues and teachers. To facilitate management and implementation, teaching is typically conducted in class units. As a result, neither guidance nor management is sufficient, and differences among students are ignored.

(5) The comprehensive experiments lack good supervision and a continuous improvement mechanism. At present, the evaluation and supervision mechanism for the quality of week-long comprehensive-experiment instruction is relatively simple and not sufficiently comprehensive, mainly depending on self-motivation. This makes it impossible to continuously improve the mechanism, and supervision and improvement are unable to form a beneficial loop.

3. Obe-based Reform of Instruciotn in Comprehensive Experiments for Electronics Majors

Comprehensive experimentation combines multiple pieces of knowledge from the practical course of study to undertake systematic application. On the basis of mastering theoretical knowledge and basic experimental skills, students must also integrate the disciplinary knowledge they have acquired. Students design and implement experiments using strategies such as intercrossing, permeating, combing, and innovating, thereby honing their experimental skills. By introducing OBE into comprehensive-experiment instruction and adopting a results-

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oriented approach, we can design effective instructional content, break with traditional teaching and assessment methods, and situate the student at the center of the process. Using different methods to guide students, we can cultivate independent learning, stimulate students' creativity, and improve the educational effect of the comprehensive experiments.

3.1. Results-oriented Goal Adjustment of Comprehensive Experiments

Results-oriented OBE refers to establishing expected educational results in consideration of the market demand for talent, school training positioning, and the levels of individual students. OBE emphasizes that education evaluation is based on results—that is, the degree to which learning output and training goals are achieved. Combined with the requirements for engineering accreditation, the educational objectives of electronics majors in the author's school are broken down into four indicators: (1) master basic theoretical knowledge and skills in a given discipline; (2) be able to analyze and solve engineering problems; (3) be able to innovate, conduct research, carry out electronic product development, and achieve technical transformation; and (4) be able to serve society, become the technical backbone of a given position, and continue to grow as an engineer. Based on these educational goals, electronics majors' comprehensive experiments should be based on acquiring theoretical knowledge and conducting basic validation experiments. Students should be able to apply the technical content of the course, design plans for experiments and solve practical problems. This will comprise a test of students' ability to transform theoretical knowledge into practical skill.

3.2. Updating the Content of Comprehensive Experiments Based on A Results Orientation

Under OBE, the goal of comprehensive-experiment instruction is oriented toward industry needs; that is, educational goals are set and courses are designed according to industry requirements. The design of comprehensive experiments reflects the multidisciplinary and interdisciplinary nature of electronics and integrates the concept of engineering education. Instead of using a single topic for the whole class, multiple topics can be selected in various ways. They can be self-made or selected from a project topic bank; they can be competition projects or tutoring projects. There are no restrictions, but each topic needs to have a must-complete item and expansion items. Each semester, screening can be undertaken according to the teaching objectives for the comprehensive experiments, taking into consideration evaluation feedback from previous years.

3.3. Results-oriented Reform of Comprehensive-experiment Instruction Methods

Based on OBE, which emphasizes flexibility, teachers can adopt flexible teaching methods and different evaluation approaches according to individual students, provided the original educational goals are reached. In this approach, instruction in comprehensive experiments is mainly student centered and results oriented. Stronger students can work on their own while students with weaker abilities can work in groups of two or three. For students with different levels of ability, stepwise experimental questions can be established for everyone to choose from. Comprehensive experiments are basically carried out in an open laboratory that provides students with a venue and equipment. The instructor is responsible for guidance, ensuring that the required work is completed within a week and that each person completes the expansion-item content according to his or her own ability.

Students are grouped according to the enterprise model. After they accept a task, they imitate a project team establishing an enterprise, undertake team and labor division, and simulate many practical aspects of the enterprise. In each step, through literature collection, market surveys, and questionnaires, the project team collaborates, undertakes design, discusses and solves problems, and finally hands in a results report and statistical analyses to the teacher.

This process focuses on students' independence in learning, design, debugging, and problem-solving. The teacher only assists in providing guidance and answering questions.

3.4. Results-oriented Reform of Comprehensive-experiment Evaluation

Assessment of the comprehensive experiment mainly focuses on defending one's experimental project. Scores are determined through on-site demonstration, defense, and discussion. Based on the student-centered, results-oriented practical teaching assessment method, strengthening basics in "individual ability + result" evaluation can improve the three-dimensional "teamwork ability + process" assessment method.

Prior assessment methods, based on final results and teacher assessment, are changed to focus on assessing the entire experimental process, implementing the double-layered evaluation of "process + results." First, teachers conduct process evaluations based on students' individual performance in the classroom where the experiment was performed. Attendance, learning logs, other personal performances, problem solving, team performance, team discussion, and defense sessions are used to further assess student participation and their ability to solve problems during the experimental process. Second, the results are evaluated based on the students' division of labor, the completion of team tasks, the final experimental data, and the writing of the report. The results are evaluated to assess the completion of the students' tasks. The three-dimensional "process + results" evaluation method can more thoroughly assess students' overall disciplinary knowledge, especially with regard to achieving targeted results, such as practical, innovative, and teamwork abilities, as well as the overall level of quality.

3.5. Constructing A Feedback Mechanism Based on Results-oriented Comprehensive-experiment Evaluation

As a core facet of OBE, "continuous improvement" runs throughout the entire process of comprehensive-experiment instruction to ensure quality and the achievement of teaching goals. By analyzing students' learning situations and the learning results for each index point, a comprehensive evaluation of the actual learning results can be obtained. A scientific evaluation and feedback mechanism is a prerequisite for continuous improvement. Through the use of questionnaire surveys, student seminars, and using questionnaires to follow up on graduates working in related fields, experimental objectives, content, modes, and assessment methods can be dynamically adjusted in real time. A beneficial loop is formed between teaching, evaluation, feedback, and improvement, thereby achieving continuous improvement.

4. Conclusion

Electronics programs aim to produce high-quality talent who can adapt to rapid developments in science and technology. Instruction in comprehensive experiments is an important aspect of electronics education. It helps students master professional skills, analyze and solve problems, and gain an awareness of innovation. Under the guidance of the OBE concept, comprehensive experiments can be used to consolidate students' classroom knowledge and improve their engineering literacy and innovation abilities.

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