Exploration of the Course System of Signals and Systems Based on Outcome-Based Education

Zhongmin Li[1,a] and Min Ma[2,b,*]

[1] School of Information Engineering, Nanchang Hangkong University, Nanchang 330063, China
[2] School of International Education, Nanchang Hangkong University, Nanchang 330063, China

[a]zhongmli@163.com, [b,*]grace9923@163.com

Abstract. Currently, the concept of Outcome-Based Education (OBE) has been introduced more and more into the teaching of Signals and Systems course for electronic information majors. However, there are still some problems with students' lack of advanced thinking ability, insufficient innovation ability and weak sense of achievement. In order to solve the above problems, according to the OBE concept of "student-centered and outcome-based", we propose a course system of Signals and Systems for electronic information majors based on the OBE concept which mainly includes six steps: course objective and orientation, teaching content and design, course resource construction, course organization and implementation, course grade evaluation, course evaluation and reform effect. Under the guidance of the OBE concept, we innovatively and closely combines with the "two features and one degree ", emphasize both mathematical deduction and physical meanings, and construct a trinity advanced course content system: clarify the three-dimensional advanced course objectives of the course's knowledge, ability and quality, expand the advanced course content, and improve the comprehensive ability of students to analyze complex problems; Empower teaching with scientific research, guide students to participate in discipline competitions, and cultivate students' abilities of innovative thinking; Expand the group discussion topics, increase the research, innovation and comprehensive content, and enhance the sense of achievement of students.

Keywords: Outcome-Based Education, Signals and Systems, Course System, Teaching steps.

1 Introduction

The course of Signals and Systems is a fundamental course for various majors in electronic information, which basic principles and methods are widely used in various fields such as electronic information engineering, communication engineering, electrical engineering, automatic control, and computer information processing. It plays a connecting role in the curriculum system, and its teaching content is closely related to the previous and subsequent courses, which plays a very important role in the talent training

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program of undergraduates majoring in electronic information. The teaching objective of this course is to enable students to master the basic theories, basic principles and methods of signals and linear systems analysis, and to flexibly apply these methods in the subsequent courses to solve the problems encountered. However, Signals and Systems is a highly theoretical course with mathematical derivation as the core. Its concepts are relatively abstract, requiring high mathematical knowledge, and mathematical calculations are cumbersome. Moreover, the analysis results lack visual and intuitive representation, making it difficult for students to understand the practical application of the results in signal processing. Due to the large amount of teaching content and heavy teaching tasks, in classroom teaching, teachers mainly focus on explaining principles and deducing formulas, and most students are in a passive learning state. Many students treat Signals and Systems as mathematics, so they are easy to feel bored and lose interest in learning, resulting in low initiative and enthusiasm for learning.

Since the 1980s, the American education community proposed an Outcome Based Education (OBE) model. American scholar Spady [1] defined OBE in his book "Output Based Education: Controversy and Answers" as " clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences." Harden at al. [2] elaborated its connotation in detail. In recent years, many scholars have introduced the OBE concept into the teaching of Signals and Systems. Ji et al. [3] introduced the OBE concept to enhance the core competitiveness of students and improve the quality of personnel training. Aiming at engineering education, Wang et al. [4] explored a teaching system of Signals and Systems course based on OBE. According to results-oriented requests and ability training requirements, Zhang et al. [5] designed teaching objectives, teaching process design and assessment, and evaluation mechanism. Tian et al. [6] explored its teaching objective, teaching method design and outcome evaluation based on online teaching characteristics. Zhou et al. [7] continuously improved Signals and Systems course of electrical major based on OBE. Bao et al. [8] took "the definition and characteristics of convolution sum" as an example to elaborate on the student-centered and output-oriented teaching content design. Wang [9] proposed an online and offline mixed teaching model of "learning-teaching interaction" based on "student-centered and outcome-oriented". Based on the OBE education concept, Liang et al. [10] carried out reverse classroom design, stimulated students' subjective initiative and cultivated their practical abilities. Zou et al. [11] presented a Signals and Systems teaching method of "flipping & intelligence classroom" based on the construction of new engineering. Jing et al. [12] designed the details of the six stages of the assessment system based on the OBE innovatively, including positioning, goals, plan, implementation, evaluation, and reflection.

Under the guidance of the OBE concept, the current key issues to be addressed in the teaching reform of the Signals and Systems mainly include the following three:

(1) In response to the problem that the theoretical knowledge of this course focuses more on physical meanings than mathematical derivations, and the breadth and depth of the course content are insufficient, resulting in students' insufficient understanding of basic principles and lack of advanced thinking ability, how to formulate advanced

course objectives and expand advanced course content so that students can have excellent theoretical foundations and then have comprehensive abilities to analyze complex problems?

(2) In response to the problem that most of the example problems in this course are analyzed around ideal mathematical models, which are detached from engineering reality and cannot stimulate students' learning enthusiasm and cultivate their innovation ability, how to combine scientific research and engineering practical cases, and use modern information technology to guide students in exploratory and personalized learning, so as to develop their innovative thinking abilities?

(3) In response to the lack of research, innovation, and comprehensive content in classroom teaching of this course, which leads to insufficient student engagement and a weak sense of achievement, how to extend classroom teaching beyond the classroom, strictly assess and evaluate, and increase students' learning engagement, so as to enhance their sense of achievement in improving their abilities and qualities?

In order to address the three key issues mentioned above, following the OBE philosophy of "student-centered, outcome-based ", we design the teaching steps of the Signals and Systems in detail, and construct a trinity high-level course content system.

2 Overall Design of Course Teaching System

The teaching system of this course mainly includes six steps (see Fig. 1): course objective and orientation, teaching content and design, course resource construction, course organization and implementation, course grade evaluation, and course evaluation and reform effect.

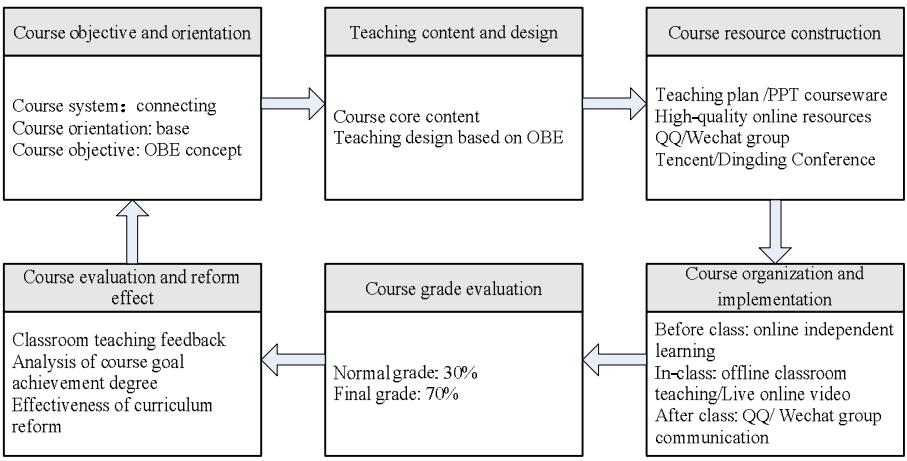

Fig. 1. Design of the teaching system of Signals and Systems course.

3 Implementation of Teaching Steps

3.1 Course Objective and Orientation

This course plays a connecting role in the electronic information major curriculum system, and is positioned as a fundamental course of the major. In accordance with the OBE concept and corresponding to the observation point of graduation requirements, the knowledge, capability and quality are organically integrated and progressively developed into multi-dimensional and advanced course objectives of this course.

3.2 Teaching Content and Design

Under the background of the new era, the Ministry of Education has put forward the quality standard of curriculum construction of "two features and one degree", that is, "promoting advanced nature, highlighting innovation and increasing challenge degree". The core content of this course mainly includes convolution integral/convolution sum of time domain analysis, and Fourier transform /Laplace /z transform of frequency domain analysis, which is also the key content of the examination of graduate students in many universities and related majors. On this basis, it is closely combined with the "two features and one degree" and attaches equal importance to mathematical derivation and physical meaning to construct a trinity advanced course content system. Firstly, the classroom teaching content is expanded from the breadth and depth, including correlation function, two-dimensional convolution, sampling theorem, zero-pole distribution diagram and digital filter and other advanced course content. Then, the research enabling teaching will introduce the scientific research results of the teaching team into the course teaching, combined with scientific research and engineering examples, in-depth exploration of the above advanced course content, and guide students to participate in various discipline competitions. Finally, based on the advanced course content, the group discussion topics outside of class will be extended to add research-oriented, innovative, and comprehensive content.

3.3 Course Resource Construction

In order to effectively implement the above advanced course content, relevant teaching resources have been continuously constructed.

(1) Continuously updated and improved the course teaching plan and teaching PPT courseware.

(2) In order to facilitate the development of online teaching, high-quality online resources have been established on the Learning Channel, including teaching videos, micro-class videos, courseware, teaching plans, in-class tests, problem sets and other online resources.

(3) In order to facilitate online question-answering and after-class communication, we have also established QQ/ wechat teacher-student groups for teaching classes.

(4) At the same time, online live teaching is also carried out through Tencent/Dingding conference.

3.4 Course Organization and Implementation

Under the guidance of the concept of "student-centered, outcome-oriented", different teaching methods are adopted according to different teaching contents and teaching objectives, and teaching is carried out from simple to deep. The main teaching methods include independent learning, classroom teaching, case teaching and group discussion.

The organization and implementation of the course are as follows:

(1) Before class, students use the online learning resources to start independent learning and complete online exercises.

(2) In the class, the classroom teaching adopts heuristic teaching, allowing students to deepen their understanding through classroom exercises, and moderately flip according to the teaching content. Online teaching can also be carried out through Tencent/Dingding conference live streaming. Furthermore, complete in-class quizzes/quizzes and assignments.

Combining the key content with engineering practice, case teaching is adopted to guide students to participate in various discipline competitions and cultivate students' engineering literacy.

(3) After class, we will interact with each other through QQ/ wechat group and arrange group discussions. Expand the teaching content through the topic discussion, and cultivate the students' abilities to consult literature and conduct research.

3.5 Course Grade Evaluation

Course grades are assessed by process assessment. Classroom tests can be conducted offline or online. In group discussion, students focus on literature review and program design. Traditional homework and final exams are maintained, urging students to carry out excellent theoretical study.

3.6 Course Evaluation and Reform Effect

According to the homework, classroom tests, group discussions and comprehensive analysis of exam scores of many students, the teaching reform of this course has achieved remarkable results. Most students have a thorough understanding of the mathematical formulas and physical meanings of the basic principles of Signals and Systems, and have the comprehensive abilities to analyze complex engineering problems in the field of electronic information and innovative thinking abilities.

The results of the reform are mainly reflected in the postgraduate entrance examination rate of students and the award of discipline competitions.

The postgraduate entrance examination rate of students majoring in electronic information engineering in the past three years has been significantly improved, exceeding 30% in 2021 and 2022.

In recent years, members of the teaching team have guided students to participate in various disciplinary competitions such as the National Electronic Design Competition for College Students and the National Intelligent Car Competition for College Students, and won a series of awards.

4 Conclusions

Base on the OBE, we innovatively integrate with the concept of the "two features and one degree", emphasizing both mathematical deduction and physical meanings, and construct a trinity advanced course content system: Clarify the three-dimensional advanced course objectives of knowledge, ability, and quality, expand the content of advanced courses, and enhance students' comprehensive ability to analyze complex problems; Empower teaching with scientific research, guide students to participate in subject competitions, and cultivate students' innovative thinking abilities; Expand the group discussion topics, add research-based, innovative, and comprehensive content, and enhance students' sense of achievement.

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