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Course Construction of *Signals and Systems* for New Engineering Education

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Abstract: The current engineering education in universities still generally faces problems such as insufficient interdisciplinary mechanisms, redundant course content, and a disconnect between theory and practice, making it difficult to meet the demand for composite talents in the new engineering field. This paper focuses on the interdisciplinary integration of different engineering majors in the construction and implementation of the course "Signals and Systems". It constructs a modular curriculum system, teacher collaboration mechanism, and teaching resource co-construction, which can ensure the characteristics of each major and maximize resource efficiency, providing a replicable paradigm for the integration of interdisciplinary courses in engineering education; Based on the overall architecture of the course groups of "Fundamentals of Circuit Analysis", "Signals and Systems", and "Digital Signal Processing", course collaboration is achieved through knowledge chain integration and ability gradient cultivation, achieving seamless integration of course group content; By conducting engineering cases and practical research, we aim to solve the problem of strong theoretical knowledge and weak engineering applications, which can meet the innovative needs of new engineering teaching. The teaching team has conducted relevant teaching reform attempts and explorations in teaching practice, promoting the improvement of teaching quality and effectively assisting in the cultivation of innovative, versatile, and application-oriented talents, which has broad promotion value.

Keywords: Course construction, Signals and Systems, interdisciplinary integration, new engineering education.

1. Introduction

The core characteristics of new engineering education are cross integration, innovation, practicality, and dynamic adaptability, emphasizing deep integration between disciplines, collaboration of industry and education, and cutting-edge technology empowerment to solve complex engineering problems [1-6]. However, there are still common problems in current engineering education of universities, such as insufficient interdisciplinary mechanisms, redundant and fragmented course content, and a disconnect between theory and practice, which make it difficult to meet the needs of cultivating interdisciplinary and composite talents in new engineering education [7-12].

Focusing on the construction of the "*Signals and Systems*" course of three majors, i.e. electronic information engineering, automation, and robotics engineering, we break down disciplinary barriers and solve the integration of course construction and implementation in different majors by building a modular course system, teacher collaboration mechanism, and teaching resource co construction; Based on the overall architecture of the course groups of "*Fundamentals of Circuit Analysis*", "*Signals and Systems*", and "*Digital Signal Processing*", we construct a progressive course system of "Basic Theory - System Analysis - Engineering Implementation", eliminating content redundancy and gaps, and achieving collaboration among various course contents in the course group; By combining engineering cases with practical research projects, we aim to solve the problem of emphasizing theory too much and neglecting practice in the course, and promote the deep integration of theoretical teaching and engineering applications.

2. Interdisciplinary Integration of Different Engineering Majors

2.1. Building a Modular Curriculum System

A modular curriculum system has been constructed, including core modules (accounting for about 70%) and professional expansion modules (accounting for about 30%). For the three different majors, the teaching content of the core modules is unified, and a common knowledge framework (analysis of signal and system characteristics, Fourier transform/Laplace transform, etc.) is extracted. While the professional expansion modules of the three different majors each have their own focuses: for example, electronic information engineering focuses on communication system modeling, automation strengthens the application of control theory, and robotics engineering highlights electromechanical signal processing.

2.2. Establishing the Collaborative Mechanism for Teaching

We hold a joint discussion activity on teaching once a month, where teachers listen to each other's lecture and provide constructive opinions and suggestions. The teachers jointly build a project case library, collecting typical engineering cases from various professional fields and jointly developing interdisciplinary cases. In addition, teachers also build an exam paper library together with unified assessment requirements and formats, and share the part involved in the core teaching modules.

The achievements of resource construction include uploading 35 recorded course videos and 50 teaching PPTs (including engineering application teaching cases and course ideological and political teaching cases) in cloud classes, and building a test paper library (including 20 test papers+20 standard answers). By using the above methods to solve the problem of integrating the construction and implementation of the "Signal and System" course in different majors, it is possible to ensure professional characteristics while maximizing resource efficiency, providing a replicable paradigm for cross disciplinary course integration in engineering education.

3. Curriculum Collaboration based on Overall Architecture of the Course Group

In the undergraduate training system, each major course corresponds to a prerequisite course and a follow-up course. Some courses even form strongly related course group, but there are often problems of content redundancy and gaps between each course. This paper proposes to sort out the course content and relationships, construct a progressive course system of "Basic theory-System Analysis-Engineering Implementation". We clarify the relationship between "*Fundamentals of Circuit Analysis*", "*Signals and Systems*", and "*Digital Signal Processing*" in the course group. We not only build a three-tier progressive knowledge architecture, but also design a knowledge point connection matrix to optimize course content, eliminate redundancy and gaps in each course content in the course group, and achieve course collaboration.

3.1. Building a Three-layer Progressive Knowledge Architecture

For the course group of "*Fundamentals of Circuit Analysis*", "*Signals and Systems*", and "*Digital Signal Processing*", we have constructed a three-layer progressive knowledge architecture shown as table 1. The bottom layer "*Fundamentals of Circuit Analysis*" focuses on time-invariant lumped parameter circuit modeling, the middle layer "*Signals and Systems*" highlights the "time domain-frequency domain" conversion and constructs a linear time-invariant system analysis framework, and the high-level "*Digital Signal Processing*" strengthens discretization processing techniques and uses MATLAB to implement spectral analysis and digital filter design.

Table 1. Three-layer Progressive Knowledge Architecture of the Course Group

Level	Fundamentals of Circuit Analysis	Signals and Systems	Digital Signal Processing
Research Subject	Lumped Parameter Circuit	Continuous Signal and LTI System	Discrete Signals and Digital Systems
Mathematical Tools	Differential Equation/Preliminary Analysis of Complex Frequency Domain	Fourier Transform/Laplace Transform	Z-transform/ DFT/ FFT
Core Ability	Circuit Modeling and Parameter Calculation	System Characteristic Analysis and Comprehensive Capability	Design and Implementation of Digital Algorithms
Typical Applications	RLC Circuit	Modeling of Communication Systems/Filter Design	Speech Processing/Image Processing/ Biomedical Signal Processing, etc.

3.2. Designing the Knowledge Point Connection Matrix

Based on the three-layer progressive knowledge architecture, we also design a knowledge point connection matrix shown as table 2 to achieve the full chain cultivation logic of "circuit-signal-system-algorithm".

Table 2. Knowledge Point Connection Matrix of the Course Group

Connection Point	Fundamentals of Circuit Analysis →Signals and Systems	Signals and Systems→Digital Signal Processing
Time Domain Analysis	RLC Circuit Response→System Impulse Response	Continuous Convolution Theory→Discrete Convolution Theory
Frequency Domain Analysis	Circuit frequency characteristics→System Frequency Response Function	Fourier Transform→Discrete Fourier Transform
Stability of Systems	Distribution of Poles→Stability Criteria of Systems	Stability Conditions for Continuous Systems→Stability Conditions for Discrete Systems
Implementation of Filters	Conception of Analog Filters→System Function Construction	Analog Filter Prototype→Design of Digital Filters

3.3. Rebuilding Contents of the Curriculum System

The discrete parts of the courses "*Signals and Systems*" and "*Digital Signal Processing*" have overlapping teaching content. The time-domain analysis of discrete-time systems and Z-transform are mandatory topics in the "*Signals and Systems*" course, and can be reviewed for no more than 4 hours in the "*Digital Signal Processing*" course. However, it should be noted that review is not simply repetition, but rather a supplementation of content from the perspective of discrete signal and system analysis. The symbols of the two courses must also be uniformly represented. For the Discrete Fourier Transform (DFT) included in both courses, it is more reasonable to study DFT in the "*Digital Signal Processing*" course, as "*Digital Signal Processing*" is a deep learning and research of discrete signals and systems.

The content related to the design method of analog low-pass filters is not yet included in the courses of "*Signals and Systems*" and "*Digital Signal Processing*". It should be supplemented in "*Signals and Systems*" to lay the foundation for the design of digital filters in "*Digital Signal Processing*". In addition, the sampling theorem in "*Signals and Systems*" must be taught as a key preparatory knowledge for "*Digital Signal Processing*".

4. Practical Teaching by Combining Engineering Cases and Research Projects

To solve the problem of emphasizing theory too much and neglecting practice in the course, we take the following three progressive measures. Firstly, we replace traditional confirmatory experiments with design oriented and comprehensive experiments to strengthen engineering thinking training; Secondly, we use engineering case teaching to achieve closed-loop training from theory to practice, in order to solve the problem of missing engineering application scenarios; Finally, we guide students to participate in teacher research projects, and encourage them to independently apply for college student innovation and entrepreneurship projects. Through the above measures, students have significantly improved their ability to solve complex engineering problems, and achieved the enhancement of knowledge application ability and innovation literacy.

5. Conclusion

We have built a modular curriculum system of core modules (accounting for about 70%) and professional expansion modules (accounting for about 30%) to achieve an organic unity of common foundations and differentiated training for different majors; Through teacher exchange and joint teaching, we have jointly develop interdisciplinary cases library, an exam paper library, and standardized assessment systems, providing scalable solutions for cross disciplinary collaboration in engineering courses. We have also innovated the knowledge chain integration and progressive ability development system of the course group, including constructing a three-layer progressive knowledge architecture and designing a knowledge point connection matrix, and systematically eliminating content redundancy and gaps between courses. We have also innovated the comprehensive practical teaching system to break through the traditional dilemma of "emphasizing theory over practice".

Through the above reforms and practices, a cross disciplinary integrated professional course construction model has been formed, providing a replicable paradigm for cross disciplinary course construction in engineering education, benefiting multiple classes and students in the three majors of electronic information engineering, automation, and robotics engineering. The educational achievements of the reforms and practices include multiple high-level competition awards for students, approval and outstanding completing of student innovation and entrepreneurship projects, and obtaining excellent undergraduate graduation designs of Beijing level. This indicates the course construction of *Signals and Systems* for new engineering education that we conducted can effectively help achieve the goal of cultivating innovative, compound, and applied talents and has broad promotion value.

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