Research on Teaching Reform of the Signals and Systems Course for Automation Specialty from the Perspective of Applied Talent Cultivation

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Abstract: From the perspective of applied talent cultivation, this paper conducts an in-depth analysis of the main problems existing in the teaching and learning of the Signals and Systems course for the Automation specialty. It explores teaching models and cultivation mechanisms more suitable for applied talent cultivation, proposing specific solutions such as optimizing course content settings, improving teaching methods, and enhancing collaborative education mechanisms. Through these reform explorations, the study aims to improve the teaching quality of the Signals and Systems course for the Automation specialty, laying a foundation for cultivating applied talents with solid theoretical foundations, strong practical abilities, and innovative spirit.

Keywords: Applied Talent Cultivation; Automation Specialty; Signals And Systems; Teaching Reform

1. Introduction

With the rapid development of economy and technology, various sectors of society demand a large number of applied talents possessing solid professional theoretical knowledge and the ability to solve practical problems. A major objective in organizing and implementing the National Medium- and Long-Term Education Reform and Development Plan Outline is to cultivate a cohort of high-quality, professional applied technical talents with strong innovative capabilities who can meet the needs of economic and social development [1-2]. The implementation of the "Professional Certification for Undergraduate Engineering Education in Regular Higher Education Institutions" not only assesses the talent cultivation capabilities of domestic engineering colleges but also provides globally recognized credentials for engineering and applied technical talents with innovative and practical abilities [3-4]. As an important field for cultivating engineering technical talents, the Automation specialty relies heavily on its foundational theoretical course, Signals and Systems, which plays a crucial role in talent cultivation [5-7]. However, the current teaching of this course still exhibits some problems in adapting to applied talent cultivation, necessitating urgent teaching reforms. Against the backdrop of research on teaching foundational theoretical courses for the Automation specialty oriented towards applied talent cultivation, this study uses the Signals and Systems course as an example. By analyzing the main problems in current teaching, it explores reforms for foundational professional courses centered on the core issue of applied talent cultivation. The goal is to improve the talent cultivation model for relevant specialties, enabling graduates to integrate more quickly into production practice and thereby enhance the quality of applied talent cultivation.

2. Main Problems

Signals and Systems is a course that employs appropriate mathematical methods (time-domain methods, convolution methods, frequency-domain analysis, complex frequency-domain (s-domain) analysis, and z-domain analysis) to process signals during their transmission through systems. Prerequisite courses include advanced mathematics, circuits, and other foundational subjects. Follow-up courses include specialized subjects such as Automatic Control Principles, Modern Control Theory, and Process Control Systems. The course requires students to master the fundamental concepts of signals and systems, basic methods of system analysis, and their interrelationships. Building on this, students should apply the acquired knowledge to engineering practice, providing a solid foundation for subsequent research, study, and work. Taking our university's Signals and Systems course as an example, the talent cultivation plan allocates 51 theoretical hours plus 9 practical hours. The course mainly covers chapters on basic concepts of signals and systems, time-domain analysis of continuous systems, time-domain analysis of discrete systems, Fourier transforms and frequency-domain analysis of systems, s-domain analysis of continuous systems, z-domain analysis of discrete systems, system functions, etc. The course features numerous knowledge points, limited class hours, and a heavy teaching load. Based on years of teaching practice, the following problems have been identified.

2.1 The Aspects of Course Content

Firstly, the content is excessively theoretical and lacks close ties to practical applications. The Signals and Systems course is highly theoretical, involving substantial mathematical derivations and abstract concepts. During teaching, excessive focus is often placed on imparting theoretical knowledge while neglecting its integration with practical applications. Students find it difficult to understand the practical significance of the course content, leading to low learning interest. For example, when explaining the Fourier transform, students often merely memorize the formulas and derivation process without understanding its applications in real-world engineering. Secondly, the teaching content is extensive yet lacks systematic organization. The course contains a multitude of formulas. Without systematically summarizing the relationships between chapters, students' difficulty in mastering relevant knowledge points increases progressively as the course advances. Thirdly, content updates are slow, resulting in a serious disconnect between theory and engineering applications. The current course content updates relatively slowly, failing to promptly reflect new theories and technologies in the field of signals and systems. The gap between the knowledge students learns and its actual application affects learning outcomes and the enhancement of professional competence, deviating from the goal of applied talent cultivation.

2.2 The Aspects of Teaching Methodology

On one hand, teaching methods are singular and lack interactivity. Traditional teaching methods primarily rely on lecturing, with students passively receiving knowledge. This approach lacks interactivity, making it difficult to stimulate student interest and initiative. Simultaneously, due to the abstract nature of the course content, students are prone to fatigue and boredom during learning. For instance, regarding knowledge points on time-domain and frequency-domain analysis of systems, textbooks often merely explain theoretical knowledge in a fragmented manner. Students struggle to understand the differences and connections between these two analysis methods, leading to apprehension. On the other hand, practical teaching components are weak. Signals and Systems is a course that combines theory and practice, yet the practical teaching component commonly suffers from insufficient hours, monotonous content, and outdated experimental equipment. During practical sessions, students often merely conduct simple verification experiments according to lab manuals, lacking the ability to analyze and solve practical problems. For example, in experiments on signal acquisition and processing, students merely follow the steps in the manual without knowing how to select appropriate acquisition equipment and processing methods based on actual requirements.

2.3 The Aspects of Faculty Team

Firstly, some teachers entered teaching positions directly after graduation and lack practical engineering experience. Consequently, they struggle to integrate theoretical knowledge with practical applications during teaching, unable to provide students with vivid engineering cases and practical guidance. Secondly, some teachers lack flexibility in applying teaching methods and tools, and their teaching proficiency, enthusiasm, and initiative need improvement.

2.4 The Aspects of Collaborative Education Mechanism

Problems mainly exist in two areas: insufficient depth in university-enterprise cooperation and inadequate closeness in industry-academia-research collaboration. Although some cooperation exists between universities and enterprises, the depth and breadth are insufficient. Enterprises lack enthusiasm for participating in talent cultivation, failing to provide students with adequate practical opportunities and internship positions, hindering resource sharing and complementary advantages. The lack of effective collaborative platforms and mechanisms between universities, enterprises, and research institutions also prevents genuine industry-academia-research collaboration. This deprives students of opportunities for innovative practice and platforms, also impacting faculty research levels and the improvement of teaching quality.

3. Solution Methods

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3.1 Optimizing Course Content Settings

On one hand, strengthen the integration of theory with practical applications. Main approaches include:

(1) Introduce numerous real-world engineering cases during teaching to help students understand the practical application value of course content. For example, when teaching the Sampling Theorem, use the example of an Eight-Tone Knock Piano. By changing the sampling frequency of a voice acquisition system (**Figure. 1**), allow students to intuitively perceive the characteristics and differences in the output sound at different sampling frequencies (**Table 1**), and analyze the reasons for these phenomena. Combining concrete life examples with course theory helps students better grasp the knowledge points and their applications.

(2) Increase practical teaching hours and enrich practical teaching content. Offer comprehensive experiments, course design projects, and other practical sessions, enabling students to master the fundamental theories and analysis methods of signals and systems through hands-on practice. For instance, during a course design project, students could design a simple signal processing system, such as an audio or image signal processing system, applying learned theoretical knowledge to real-world engineering.

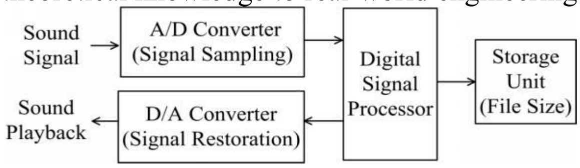

Figure 1. Schematic Diagram of Voice Acquisition System Operation Principle

Table 1. Sampling and Recovery Results of Eight-Tone Knock Piano at Different Frequencies

Sampling Frequency	File Size	Audio	Consistency
44100Hz	430KB	Recording 1	Consistent
11025Hz	107KB	Recording 2	Consistent
8000Hz	78KB	Recording 3	Basically Consistent
4000Hz	39KB	Recording 4	Inconsistent

On the other hand, effectively integrate and promptly update course content. Although the course has numerous knowledge points, they are interrelated. Systematically summarizing these relationships is expected to achieve twice the result with half the effort in teaching Signals and Systems. For example, methods for time-domain analysis of discrete systems can largely draw upon methods for continuous system time-domain analysis (Five-Step Method). The three system analysis methods – frequency-domain (using Fourier Transform), complex frequency-domain (s-transform), and z-transform – exhibit specific relationships, as shown in **Figure. 2.**

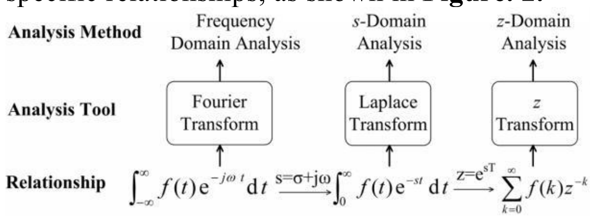

Figure 2. Three Methods of System Analysis and Their Relationships

The three major transforms (Fourier Transform, *s*-transform, *z*-transform) form one main thread (system analysis). Regarding content updates, teachers should actively follow the latest developments in the field of Signals and Systems by reading academic journals and attending conferences, integrating new theories and technologies into teaching promptly. Furthermore, active efforts should be made to cooperate with enterprises in developing course content, making it more aligned with actual application needs and further mitigating the disconnect between theory and engineering application.

3.2 Improving Teaching Methods

Teachers should employ diverse teaching methods based on course content and student characteristics, such as case-based teaching, project-based learning, and group discussions, to stimulate student interest and initiative. When explaining frequency-domain analysis of systems, case-based teaching can be applied. For example, for a signal processing procedure: first, play a noise-containing audio signal and display its time-domain waveform (**Figure. 3(a)**), analyzing how to filter out the noise using time-domain methods (highlighting disadvantages). To solve this problem, introduce frequency-domain analysis (summarized as a Four-Step Method): Step 1: Apply Fourier Transform to the signal; Step 2: Determine the system's frequency response function; Step 3: Multiply the results of Step 1 and Step 2; Step 4: Apply the Inverse Transform to the result of Step 3. Specifically: first, use the Fourier Transform to convert the above time-domain waveform into a frequency-domain waveform (**Figure. 3(b)**) and analyze its characteristics; second, select a suitable system (low-pass filter, **Figure. 3(c)**) based on the frequency-domain characteristics; third, multiply the two waveforms to obtain the spectrum of the filtered signal (**Figure. 3(d)**); finally, use the inverse transform (demodulation function of the audio system) to obtain the filtered signal's time-domain waveform (**Figure. 3(e)**), and play the audio with high-frequency noise filtered out. Then, strengthen the practical teaching component. For applied undergraduates, practical skills are often a better indicator of knowledge mastery and application ability than theoretical knowledge alone. In this course, the practical component serves as a vital platform for talent cultivation. Practical teaching hours should be increased, and content enriched, such as through the use of simulation software, operation of experimental kits (**Figure. 4**), and participation in relevant disciplinary competitions (e.g., College Student Innovation and Entrepreneurship Competition, "Challenge Cup", National Undergraduate Electronic Design Contest). This enables students to master the fundamental theories and analysis methods of Signals and Systems through hands-on practice, thereby improving the quality of practical teaching.

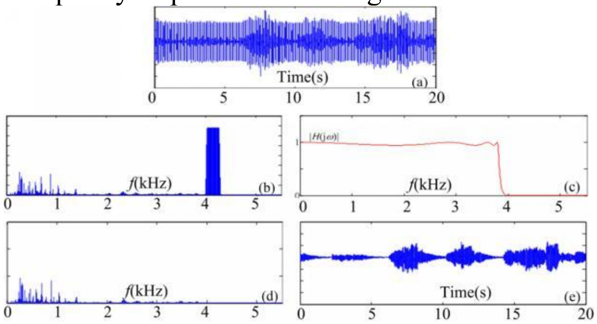

Figure 3. Four-Step Method for System Frequency-Domain Analysis

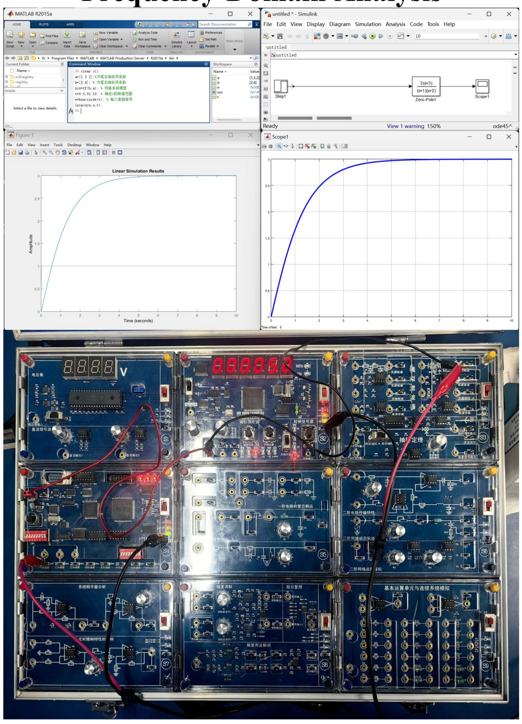

Figure 4. Partial Practical Teaching Activities for Signals and Systems

3.3 Strengthening Faculty Team Development

On one hand, enhance the engineering practical abilities of teachers. Encourage faculty to participate in enterprise internships to understand actual industry needs and technological trends. Through methods such as cooperative research and development, enable teachers to gain deep, frontline enterprise experience and accumulate practical engineering expertise. Alternatively, invite industry experts to lecture on real-world engineering cases and technological frontiers, providing students with vivid engineering examples and practical guidance to boost learning interest and practical skills. On the other hand, invite teaching experts for seminars and organize teaching observation activities to promote communication and learning among teachers, improving their ability to apply teaching methods and tools. Simultaneously, establish a scientific and reasonable teaching evaluation mechanism (incorporating student evaluations, peer reviews, teaching supervision assessments, etc.) to comprehensively evaluate teaching quality and incentivize continuous improvement in teaching proficiency.

3.4 Improving the Collaborative Education Mechanism

Firstly, establish university-enterprise cooperation platforms to strengthen communication and exchange between higher education institutions and industry. This can be achieved by setting up internship bases and collaborative cooperative research centers, providing students with practical opportunities and internship positions while offering technical support and talent cultivation services to enterprises. Furthermore, universities and enterprises should jointly formulate talent cultivation plans, optimizing curriculum design and teaching content based on actual enterprise needs and technological development trends. Enterprises can participate in course teaching and practical sessions, providing students with real-world engineering cases and practical guidance. Secondly, establish industry-academia-research collaboration alliances. Through jointly undertaking research projects and conducting technological innovation, resource sharing and complementary advantages can be realized, strengthening cooperation among universities, enterprises, and research institutions. Additionally, universities, in cooperation with enterprises, can promote the application of research findings to actual production and industrial development. This provides enterprises with technical support and innovation impetus while offering students opportunities and platforms for innovative practice.

4. Conclusions

Teaching reform of the Signals and Systems course for the Automation specialty holds significant importance within the perspective of applied talent cultivation. This paper analyzed the main problems in teaching Signals and Systems for applied talent cultivation and proposed specific reform measures concerning optimizing course content settings, improving teaching methods, strengthening faculty team development, and enhancing the collaborative education mechanism. By implementing these reforms in the teaching process, students' learning abilities, practical skills, engineering technical knowledge, and practical competence can be substantially improved, thereby enhancing the quality of applied engineering and technical talent cultivation to a certain extent.

Acknowledgments

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