

Teaching Reform of Automatic Control Theory Course Based on New Engineering Education

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Abstract: Under the guidance of the engineering education concept of the new engineering discipline, it is necessary for students to have comprehensive application and innovation ability of multidisciplinary and professional knowledge. "Automatic Control Theory" must adapt to the needs of the new era as the basic core course of automation major. This course must carry out comprehensive education and teaching reform from the aspects of course content, teaching staff, experimental setup and evaluation methods, optimize and reconstruct the new teaching mode. The professional adaptability and engineering of the course "Automatic Control Theory" determine that the education and teaching reform of this course must optimize the teaching content and teaching methods, integrate traditional knowledge and emerging technologies, train students' basic skills and innovation ability, make the course high-level, innovative and challenging in accordance with the "Golden Course" construction standard of the Ministry of Education, and cultivate automation engineering technology and innovative research talents of new engineering disciplines to meet the requirements of the new era. Based on the curriculum situation of Xi'an University of Science and Technology, this paper introduces some reform measures to provide reference for related courses and to assist in the construction of new automation engineering disciplines and personnel training.

Keywords: New Engineering, Automatic Control Theory, Curriculum Reform, Engineering Education

1. Introduction

Under the background of international engineering education, driven by the new economy characterized by "new technology, new industry, new mode and new business type", such as the Internet of Things, artificial intelligence and intelligent manufacturing, the whole society has put forward higher requirements for the knowledge, ability and quality of engineering talents in the new era [1]. Students are required to have comprehensive application and innovation ability of multidisciplinary knowledge [2, 3]. However, in order to meet the social requirements for the quantity and quality of new engineering talents, the construction of new engineering specialties in China is not only to create a number of new or emerging industrial specialties, but also to upgrade and transform traditional engineering specialties such as automation [4-6]. This transformation process must be integrated with the multi-disciplinary and multi-specialty development involved in the emerging technology industry

to strengthen the cultivation of comprehensive practical ability.

Automation specialty is a comprehensive specialty in the field of information science, involving many disciplines and specialties such as electronics, machinery, electrical, communication, computer, etc. [6, 7] It has the natural advantages of the new engineering specialty transformation. As the core course of automation specialty, "Automatic Control Theory" mainly trains students to learn the basic concepts, analysis and design methods of control system, which is an important part of the learning of follow-up courses and other professional knowledge. Therefore, in order to consolidate the students' professional foundation, how to further carry out the teaching reform in combination with the construction of new engineering majors plays a key role in strengthening the automation students' ability to integrate knowledge, analyze and design complex engineering problems and engineering practice [8-10].

2. Current Situation and Problems of Curriculum Construction

Currently, the teaching content, teaching methods, quality evaluation system and even the formation of the teaching staff of "Automatic Control Theory" in most universities are based on the knowledge of a single subject, including "Circuit Principles", "Analog and Digital Electronic Technology", "Calculus", "Complex Variable Functions" and "College Physics", etc. [11] The students have no sufficient knowledge and ability reserves related to new engineering subjects that poses a challenge to the cultivation of interdisciplinary, practical ability, teamwork awareness and international vision of new engineering talents. Although the training of innovative talents in engineering technology of new engineering courses can't be realized by relying on a single curriculum, it is believed that the systematic training of students has advantages when the new engineering education concept is integrated into the core curriculum of professional foundation. At present, there are mainly the following problems in the course construction of "Automatic Control Theory".

a) Most of the controlled systems mentioned in the current teaching materials are simple physical and chemical objects, which can be modeled by analyzing their working mechanism [12]. Most of the controllers are still given in the form of circuits. However, under the background of new economic industries such as the Internet of Things and intelligent manufacturing, the controlled objects are more and more complex and integrated, which not only makes it difficult to directly obtain the system model, but also makes the control process networked and intelligent. There is a certain disconnect between teaching content and engineering practice

b) Teachers' professional backgrounds are basically traditional automation majors and control disciplines [13]. For the construction of automation majors and curriculum reform in combination with other majors and disciplines under the background of new engineering disciplines, there is a problem of insufficient personal knowledge, practical ability or reform motivation.

c) Most of the course experiments are simple and confirmatory experiments based on the circuit experiment box or MATLAB software. In most cases, students directly discuss the so-called control system and then design the controller without understanding any engineering mechanism and process flow, and do not really establish a solid and profound basic concept and processing flow to solve complex engineering problems for students.

d) The course evaluation system focuses on the assessment of students' control system analysis ability, including control system modeling, time domain analysis, root locus analysis, frequency domain analysis and nonlinear system analysis. The content of control system design is relatively simple, and the engineering cases of control system design are rarely involved.

3. Teaching Mode Reform

First of all, it needs to be emphasized that the solution to the above problems in the teaching content, evaluation methods, teaching staff and experimental setup of the existing courses cannot be solved from a single perspective, but needs to combine the needs of engineering education of new engineering courses, take students as the center, and carry out a systematic and comprehensive reform. Therefore, this paper focuses on the following aspects to try to propose a curriculum reform plan.

a) In terms of teaching content and teaching materials, on the basis of maintaining the classical control theory to discuss various control system analysis and design methods based on accurate mathematical models, it is necessary to add some ideas and discussions on data modeling, data-driven modelless control, networked control and other methods, so as to establish a complete knowledge reserve for students [14]. Adding practical engineering cases, especially the control links and strategy analysis of intelligent manufacturing and the Internet of Things system, it is necessary to be taught at the initial stage of learning, which can not only cultivate students' correct engineering concepts, but also enhance students' interest in learning courses by combining the latest technology.

b) It is necessary to break the category of teachers in the curriculum team, to establish a curriculum group organization in relevant colleges, especially to increase the number of teachers in new industrial technologies, such as the Internet of Things, artificial intelligence, intelligent manufacturing and other courses to carry out curriculum reform, and try to employ some part-time teachers from enterprises, international famous scholars to analyze the specific control system and design process in combination with engineering cases, and to break down chapters in the form of knowledge points and special topics to broaden students' vision of international development. Of course, the teaching method can also be based on the actual content needs to carry out flipped teaching, on-line and off-line hybrid teaching. The purpose is not in what form but in the actual acceptance of students. It puts forward higher requirements for teachers to prepare lessons and students after class.

c) Relying on the new generation of information technology, we will carry out comprehensive experiments based on the control systems analysis and design that combine the virtual with the real, such as hazardous experiments such as chemical process control, and large-scale system control experiments such as intelligent manufacturing process industry, in the form of modern virtual simulation semi physical objects. This will not only dynamically display the process flow of the entire object through virtual simulation experiments, but also facilitate students to understand the control mechanism of the system. Moreover, experimental simulation in a relatively close engineering environment can also enhance students' understanding of complex control engineering problems. It is

certainly the best plan to carry out the actual control system simulation. For example, the industry specific object control can be carried out in combination with the characteristics of each school to train the students' teamwork and hands-on ability.

d) The curriculum evaluation system has shifted from individual evaluation to the combination of individual evaluation, group evaluation and project evaluation [15]. We reduce the proportion of final evaluation results such as final examination papers and experimental results, and appropriately improve the proportion of process evaluation results. In particular, the rationality and economy of the control scheme in the experimental process, the participation or management ability of team cooperation, and the innovation in the project discussion process should be improved. Even the ability of project investigation and analysis is included in the comprehensive evaluation of students' "knowledge, ability and accomplishment", and students are encouraged to present team project achievements in the form of papers and patents. The design of process evaluation links such as project discussion can only be reflected in some knowledge points, which need not be involved in all knowledge points. In addition, it needs to be coordinated with other courses in the course group.

4. Teaching Reform Experience

The Automation major of Xi'an University of Science and Technology was founded in 1985. As the traditional dominant major and brand characteristic major of Xi'an University of Science and Technology, the automation major was approved as a famous brand specialty in Shaanxi ordinary universities in 2005, a national characteristic specialty in 2009, and a pilot specialty for comprehensive reform of specialties in Shaanxi Province and an innovative experimental zone for talent training model in Shaanxi Province in 2014. In 2017, it was selected as one of first-class majors in Shaanxi Province. In 2019, it passed the on-site inspection of China Engineering Education Certification. Focusing on the needs of national and regional economic construction and based on the school's orientation and development planning, this major has formed its own school running characteristics.

a) Relying on the traditional advantages of the school, we build a training mechanism for automation professionals with coal characteristics, and train technical personnel for the coal industry who can engage in automatic control system analysis and design, technology development, operation management, etc.

b) Actively connect with the Internet of Things industry in Shaanxi Province, we provide intellectual support and talent support for the development of local characteristic economy according to the national strategic needs.

c) Closely serve the intelligent manufacturing industry in Northwest China. We constantly strengthen the talent service function of automation specialty, and provide human resources for high-end intelligent manufacturing.

The course of "Automatic Control Theory" is the first batch of excellent courses of Xi'an University of Science and Technology. The textbook compiled by our course team is the planning textbook of Coal Industry Press. By the learning of this course, students can deepen their understanding and grasp of the basic knowledge of automatic control, and learn to solve the modeling, analysis and design problems of simple control systems using basic classical control theories. At the same time, we also try to carry out curriculum teaching reform in 14 classes of automation, electrical engineering and its measurement and control specialty of Xi'an University of Science and Technology in combination with engineering education of new engineering. The main measures at present include:

- a) To update the teaching contents and textbooks. At present, the engineering simulation cases such as disk reading system, servo motor and biological fermentation process are added into the teaching content of this course to analyze the working mechanism of the control system. Then, the students can further verify and deepen the automatic control theory which they have learned through discussion and simulation, and be familiar with the basic steps to solve engineering control problems. At the same time, the new industries and new technologies such as intelligent manufacturing and artificial intelligence are added into the teaching process, so that students can analyze and think about how to combine new technologies with classical control theory from the perspective of the whole system. In addition, we add ideological and political education to the course content, providing stories about controlling scientists to improve students' interest and increase students' learning motivation. At the same time, the new digital electronic textbooks will be published, and a whole set of electronic resources such as videos and tests will be combined with paper textbooks to consolidate students' knowledge points.
- b) To set up a multidisciplinary and multidisciplinary mixed curriculum group. Considering that control knowledge is involved in the Internet of Things, intelligent manufacturing and other industries, but the emphasis on the knowledge points of this course is different, we have formed a multidisciplinary and multi-professional curriculum group of teachers with automation, electrical, Internet of Things and computer backgrounds. The curriculum group mainly includes Automatic Control Theory, Modern Control Theory, Computer Control Systems, Introduction to Internet of Things Technology, Artificial Intelligence and other courses. At the same time, we appropriately try to employ part-time teachers with rich engineering experience from enterprises outside the campus to teach practical control engineering cases. The basic knowledge of this course is explained by professional teachers in a unified way in class, but when it comes to the content of engineering education for new

engineering courses. The students can first discuss it on the public platform of the course, and then the teachers of relevant course groups can jointly answer questions and solve questions after class. The way increases the interaction between the students of different majors and the teachers of different disciplines, and builds a new engineering course teaching team and course group for multiple teachers to teach in parallel.

- c) To carry out online and offline hybrid teaching. By contrast of traditional classroom teaching and MOOC online courses, combining with the characteristics of this course, which has many knowledge points, strong logic and strong application, we will improve the construction of the "13th Five Year Plan" online open course "Automatic Control Theory" in Shannxi Province through the Internet public platform (MOOC). Under the MOOC education background, we carry out research and practice on the hybrid teaching mode of integrating online and offline information of the course, and comprehensively reform the curriculum program and teaching methods. We continuously improve the teaching method of combining flipped classroom with guided teaching. For relatively independent and complete MOOC teaching knowledge points such as "root locus analysis method of control system, control system structure diagram and signal flow diagram", students are required to completely study online within the specified time, and then carry out classroom discussion and brainstorming activities. Up to now, after three online publicity sessions, a total of 1200 people inside and outside the school have studied this course, which has also improved the influence of the course inside and outside the school.
- d) To achieve multi-dimensional evaluation ability. This course changes the evaluation method that only takes offline education results as students' abilities. We improve the evaluation method of the learning process and the rationality evaluation of the control scheme, and bring conventional homework, unit test, final exam, interactive discussion and other teaching links into the assessment link according to the actual situation of different majors. We appropriately increase the proportion of online learning scores of MOOC knowledge points by 10% - 15% to highlight the evaluation of students' autonomous learning ability. At the same time, in order to improve students' ability of engineering practice and solving complex engineering problems, we improve the difficulty of course experiments, and increase the number of comprehensive design experiments. In addition, the postgraduate assistants and the course teachers will set up a separate MATLAB simulation training after class, and students will be able to understand the control system as a whole from the perspective of modeling, analysis, design and optimization by using Simulink models of some typical projects.

5. Conclusion

In a word, the professional adaptability and engineering nature of "Automatic Control Theory" determine that the education and teaching reform of this course must make new teaching reform under the background of new engineering and engineering education. It is necessary to optimize the teaching content and teaching methods, integrate traditional knowledge and emerging technologies, train students' basic skills and innovation ability, and make the course high-level, innovative and challenging according to the "Golden Course" construction standard of the Ministry of Education. To meet the requirements of the new era, it is important to cultivate new engineering automation engineering technology and innovative research talents.

In combination with the characteristics of Xi'an University of Science & Technology, this course has carried out some practical work according to the characteristics of new engineering education. However, we need to further develop and improve in the future, such as the construction of virtual simulation experiment platform, the deep integration of technologies such as the Internet of Things and artificial intelligence with the teaching content of control theory, and the redesign of the teaching content of control engineering cases.

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