

Teaching Reform and Practice of “*The Principle of Automatic Control*” as a First-Class Undergraduate Course

Xitai Na, Zhiqiang Zheng, Zhi Weng*

College of Electronic Information Engineering, Inner Mongolia University, Hohhot, China

Email: *wzhi@imu.edu.cn

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Abstract

The Principle of Automatic Control course is the core course of the automation majors. In accordance with the key points of developing the first-class undergraduate course, the teaching team has carried out timely teaching reform to enhance the advanced, innovative and challenging features of the course. A teaching mode combining online and offline activities has been developed to reflect the “student-oriented and teacher-led” teaching philosophy. It adopts the teaching method of problem-based learning. Questions are used throughout the online and offline processes. Teachers should assign questions, and students should discuss the questions and learn cooperatively. In this way, it can help students to better understand the learning content, flexibly apply the knowledge they have learned, and enhance their ability to identify, analyze and solve problems. At the same time, teachers should grasp the main channel of classroom teaching, actively explore the ideological and political education of the course, and put equal emphasis on knowledge transfer and value leadership. In this way, teachers can work hard to foster professional and technical talents that meet the needs of society in the context of the new engineering discipline.

Keywords

The Principle of Automatic Control, First-Class Undergraduate Course, Teaching Reform, Blended Teaching, Ideological and Political Education

1. Introduction

In April 2019, the Ministry of Education proposed the “Double Million Plan”. By the end of 2021, we will build 10,000 national and provincial first-class undergraduate courses (Wang, et al., 2021b). How to seize the opportunity of national

first-class undergraduate course construction, improve the high-level, innovative and challenging nature of the “Automatic Control Principle” course, and realize the transformation of student-centered and output-oriented teaching mode is the most worthy of exploration and research in the “Automatic Control Principle” course teaching reform (Liu et al., 2023; Yan et al., 2022).

The Principle of Automatic Control is a core professional course for undergraduate majors in automation. This course comprehensively describes the basic theories and methods of automatic control systems, including the analyses, designs and applications of linear time-invariant systems, nonlinear systems and sampling control systems. This course not only features highly basic theories, but also involves strong practicality, focusing on the close integration of theory and practice. Thus, this course plays a vital role in cultivating students’ capabilities of basic theories and dialectical thinking, as well as their ability to establish a scientific viewpoint linking theory and practice and improving their ability of comprehensive analysis (Bai et al., 2021).

Inner Mongolia University started to introduce the Automatic Control Program in 1995 and offered “The Principle of Automatic Control” as a basic course. In 2002, the course “The Principle of Automatic Control” was determined as the key basic course of the university after the project application. The teaching team has undertaken comprehensive construction work in accordance with the new objectives. After more than 20 years of development, the general teaching standards and teaching quality of this course have risen to a new level. In the assessment and acceptance of the key courses in 2004, “The Principle of Automatic Control” was awarded as an excellent key course of the university. In 2005, the course was awarded as the quality course of Inner Mongolia University, and in 2007, the course was awarded as the quality course of the autonomous region. In 2015, the course was awarded the undergraduate core course project of the university, and in 2016, it was awarded the pilot course project of the university-level teaching reform. In 2019, the course was awarded the core undergraduate course project of the university and the demonstration course project of the ideological and political education. In 2019, the course was awarded the core undergraduate course project and the demonstration course project of ideological and political education at the university level. In 2020, it was awarded the first-class undergraduate course project of Inner Mongolia University, and in 2021, it was awarded the first-class undergraduate course project of the Inner Mongolia Autonomous Region.

2. Course Development Ideas and Objectives

Through the course The Principle of Automatic Control, students should be able to relate theory to practice and associate abstract mathematical models with real systems. They should understand the role of automatic control technology in the development of society and its relationship with other disciplines. After studying this course, students should acquire the basic quality to engage in related engi-

neering and technical tasks, and possess the ability to propose, analyze and solve practical engineering problems (Zheng, 2019). In the teaching process, teachers should exploit the moral education elements contained in professional knowledge, cultivate students' scientific thinking and innovative habits, foster students' grand vision of engineering, and effectively improve the quality of cultivating new engineering talents with craftsmanship. Moreover, teachers should strive to cultivate high-quality and excellent engineering talents in the field of automation engineering who develop morally, intellectually, physically, aesthetically and laboriously, with solid foundation, reasonable knowledge structure, high quality and courage to innovate (Miao et al., 2020).

3. Development of Course Content

In terms of teaching content, teachers should highlight the physical concepts and engineering background of control theories, and downplay mathematical proofs. Based on the existing practice, teachers should continue to integrate and optimize the course content, further clarify the structure and organization of the course system, and rationalize the knowledge connection between this course and related courses. In addition, teachers should further improve the course syllabus and laboratory syllabus, so that the teaching content can serve to cultivate students' innovative capabilities. At the same time, the teacher should adopt the design idea of "one vertical and three horizontal". "One vertical" refers to the main line of modeling, analysis and design methods of dynamic control systems; "three horizontal" refers to the stability, speed and accuracy of automatic control systems (Wang et al., 2021a).

3.1. Emphasizing Engineering Background with System Modeling, System Analysis and Comprehensive Design as the Main Line of the Course

The Principle of Automatic Control is a highly theoretical, practical and comprehensive course with extensive content, abstract concepts and wide coverage. Students generally feel that it is difficult to learn this course. It is the key to reform this course to enable students to master the basic principles of control theories and strengthen the cultivation of their abilities within the limited class hours. The teaching idea of the course teaching team is to start from the system of the course, put emphasis on the engineering background and highlight the cultivation of students' capabilities by taking system modeling → system analysis → comprehensive design as the main line of the course (Zhang et al., 2021).

When introducing mathematical models, system analysis methods and system design contents, the teaching team of the course should select typical examples in control engineering and highlight the engineering background. In this way, students can learn about the structural features, working principles and design requirements of the system from the actual control systems, broaden their horizons and stimulate their desire for innovation. These vivid engineering examples will cultivate and stimulate students' interest. Moreover, it allows students to

appreciate the charm of control theories and gain a profound understanding of the meaning of applying what they have learned to practice. When students analyze problems and solve them, they can acquire knowledge and improve their ability by learning the course.

3.2. Updating Teaching Contents with the Development of Control Theories

In recent years, control theories have been flourishing. In particular, significant progress has been made in the fields of nonlinear control, robust control, adaptive control, and intelligent control. The teachers of the course teaching team should select some theoretical knowledge that is consistent with the requirements of the course and introduce it to the students in the lecturing process in order to ensure the advanced content of the course. Moreover, teachers should introduce the latest trends and technologies in the development of automatic control to students in the form of lectures to expand their knowledge and cultivate their interest in exploring science and technology.

4. Reform of Teaching Mode and Students' Learning Style

We should implement the “student-centered, problem-oriented and task-driven” teaching mode in seminars, and reform the teaching mode of teachers and the learning mode of students.

4.1. Combining Traditional Teaching Methods and Modern Teaching Methods

The Principle of Automatic Control course features many formulas, a large number of drawings, and high accuracy requirements, so we adopt the teaching method combining blackboard writing and multimedia. And the MATLAB as a basic tool is organically integrated with the teaching content, because the use of MATLAB allows teachers to quickly produce the ideal results and intuitive graphs, which can effectively improve the teaching effect and efficiency.

4.2. Adopting the Teaching Methods with Engineering Cases

Teachers should teach the class with typical engineering examples, centering on inverted pendulum systems, ball and beam systems, and motor control systems, and combining theoretical knowledge with practice. Teachers should solve practical engineering problems with theories, instead of teaching a lot of empty theories. Moreover, through the elaborate design of teaching process, teachers should help students do what they learn and learn from what they do, so as to stimulate students' interest in learning (Wang et al., 2021a).

4.3. Employing Heuristic Teaching Methods

For The Principle of Automatic Control course, teachers should make full use of heuristic teaching methods, highlighting key teaching points and difficult prob-

lems, and incorporating professional examples as far as possible. In addition, teachers should ask students questions and hold discussions in class, and leave some doubts when changing teaching contents, so that students can solve problems by themselves through thinking and discussing, which improves students' initiative of learning.

4.4. Adopting the Tutoring Method That Involves a Combination of Questioning and Answering

Answering and questioning are two important forms of self-study for teachers. In studying The Principle of Automatic Control course, most of the students have a poor grasp of the course, or cannot keep up with the teacher's schedule, and they seldom take the initiative to ask the teacher for answers to their questions. Teachers should use a tutoring method that combines questioning and answering based on active questioning to put some pressure on students and to urge them to learn. For students' common questions, teachers should take the form of group tutorials to answer them uniformly or hold special discussions.

4.5. Blended Teaching Method of Rain Classroom

The traditional teaching style where students listen to teachers and teachers teach students lacks effective interaction. In order to reflect the idea of "student-centered and innovative" and to make the classroom dynamic, the teaching team adopts the blended teaching of Rain Classroom (Cao et al., 2019). "Flexible pre-class learning", "quick in-class quiz", "innovative teacher-student interaction", and "perfect assignment questions" allow the atmosphere to be active and motivate students (Qiao et al., 2021).

4.6. Introducing Task-Based and Project-Driven Practical Teaching Led by Subject Competitions

Teachers should apply flexible teaching methods in the process of practical teaching, such as case-based teaching method, task-based teaching method and project-driven teaching method. Moreover, teachers should combine theory and practice to enable students to learn from what they do and to do what they learn, so as to improve their ability to solve practical problems. Teachers should encourage students who have not done their best in their studies and have reserved their strength to develop their own experiments. In addition, teachers can utilize the "Home of Innovations of Inner Mongolia University" platform to develop students' innovation capabilities in conjunction with activities such as the China Robotics Competition and the Smart Car Competition.

5. Grade Assessment of the Course

The grade assessment of this course combines process-oriented multiple evaluation and final paper-based assessment. It is divided into four teaching sections: assignments (including post-class assignments, comprehensive tests for each

chapter, and MOOC online learning score, at 40%), discussion sessions and cooperative learning (10%), midterm exams (10%), and final exams (40%), each of which is graded separately (Liu, & Zhang, 2021).

6. Conclusion

The course has been awarded as key course, quality course, core professional course, pilot course of the teaching mode, the demonstration course of ideological and political education and first-class undergraduate course. The status and role of this course become more explicit in the teaching of undergraduate students in automation. Its teaching contents have been further optimized, teaching methods have been significantly improved, teaching conditions have been remarkably upgraded, and teaching quality and talent cultivation quality have been markedly elevated. It is gradually forming a team of teachers with reasonable structure and high academic skills. In the recent student evaluations of teaching, both the project team leader and the lecturer were ranked in the top 1/3. The teaching team of the main basic course of automation, which is mainly composed of teachers of the course group, was awarded as the teaching team of the autonomous region.

The blended teaching mode reverses the traditional classroom model consisting of “teacher’s lecture + students’ after-class assignments” to a new teaching mode consisting of “students’ pre-class study + teachers’ and students’ classroom discussion and study instructions.” It builds a true “student-centered, teacher-guided” learning environment with personalized, collaborative inquiry. As a result, students can take control of their own learning and interactions between teachers and students and among students are considerably increased. Moreover, students become more motivated to learn, and their learning efficiency is greatly enhanced, resulting in improved teaching quality.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Bai, S. J., Li, X. W., Cao J. L., & Zhang, H. (2021). Practice of Blending Teaching Reform

- of Principle of Automatic Control. *Journal of Electrical & Electronic Education*, 43, 6-8+22. (In Chinese)
- Cao, K. C., Yang, M., Zhou, Y. J., Zhao, B., & Wan, Y. H. (2019). The Teaching Reform of Principles of Automatic Control Based on OBE. *Journal of Electrical & Electronic Education*, 41, 17-21. (In Chinese)
- Liu, W., & Zhang, N. N. (2021). The Thinking of Automatic Control Principle by Online and Offline Hybrid Teaching Mode. *Journal of Zhoukou Normal University*, 38, 133-135. (In Chinese)
- Liu, Y. J., Tao, H. F., Liu, C. L., & Xu, Y. Q. (2023). Construction and Practice of “Gold Course” of Automatic Control Principle Course for New Engineering. *Journal of Higher Education*, 1, 17-21. (In Chinese)
- Miao, Y., Jiang, D. M., & Liu, Z. (2020). The Practice of Blending Teaching of Principle of Automatic Control. *Journal of Electrical & Electronic Education*, 42, 82-86+90. (In Chinese)
- Qiao, X. G., Li, P. W., Fu, L. Q., & Li, X. (2021). Research on Blended Bearing Mode of Principle of Automatic Control. *Journal of Electrical & Electronic Education*, 43, 61-63+83. (In Chinese)
- Wang, L. F., Ren, Y., & Chen, L. L. (2021a). Establishment of the Knowledge System of Automatic Control Principle Course Based on the Three-Dimensional Teaching Model. *Education and Teaching Forum*, 7, 113-116. (In Chinese)
- Wang, X., Hua, Z., Sui, J. X., Shang, N. Q., & Ma, J. Q. (2021b). Exploration on Construction of First-class Undergraduate Course of Automatic Control Principle. *Education and Teaching Forum*, 11, 71-74. (In Chinese)
- Yan, T. B., Wang, X. L., Pei, J. L., Zhang, H. Z., Luo, Z. W., & Shan, C. (2022). Teaching Innovation Reform and Practice for the Principle of Automatic Control of the Provincial First-Class Undergraduate Course. *Modern Vocational Education*, 11, 24-27. (In Chinese)
- Zhang, Q., Zhang, D. X., & Li, G. L. (2021). Research on Online and Offline Mixed Teaching Mode for Automatic Control Theory. *Journal of Electrical & Electronic Education*, 43, 31-34+60. (In Chinese)
- Zheng, Y. (2019). Exploration and Teaching Practice of Blended Teaching Mode for Automatic Control Principle Course. *Journal of Electrical & Electronic Education*, 41, 44-48. (In Chinese)